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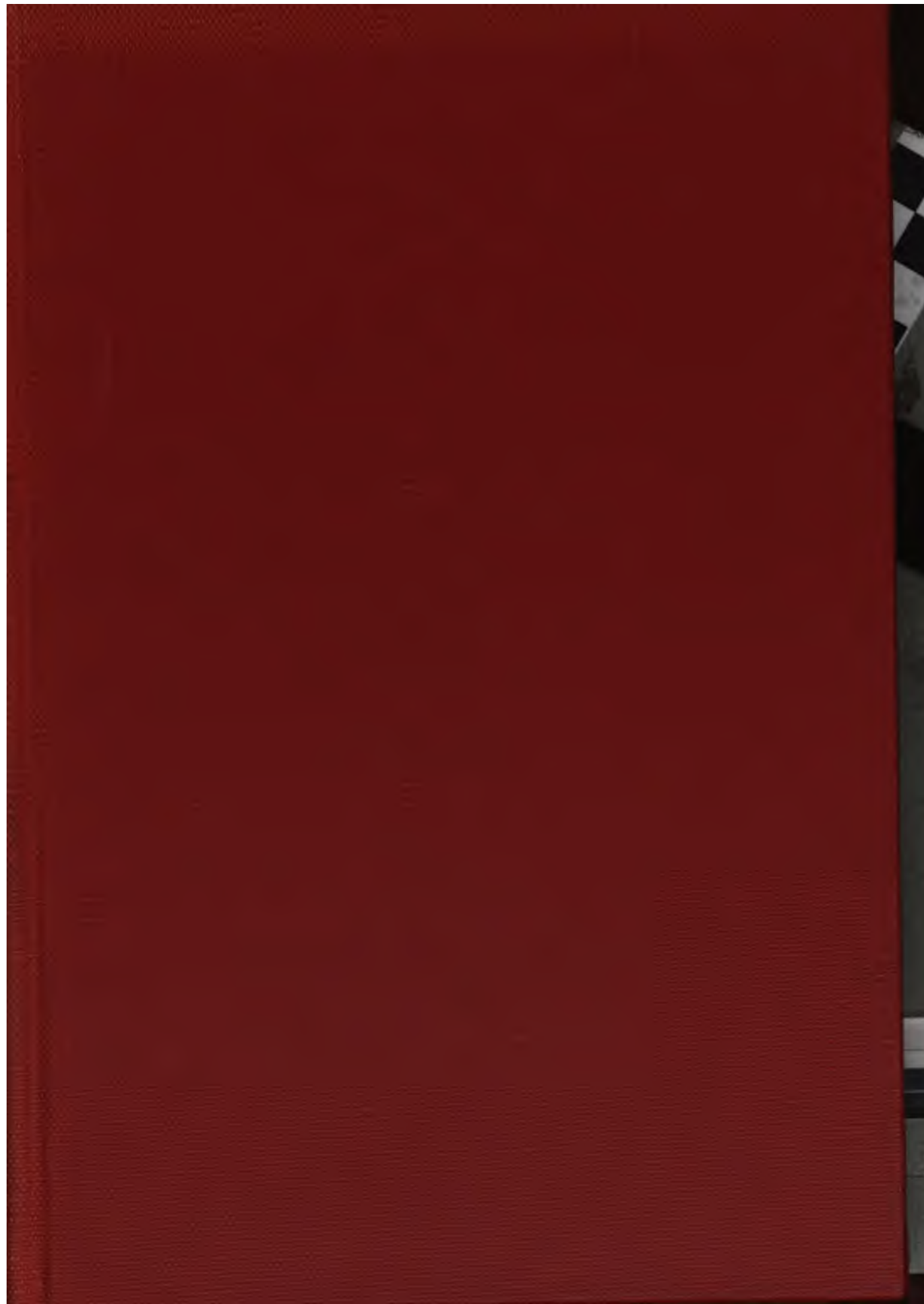
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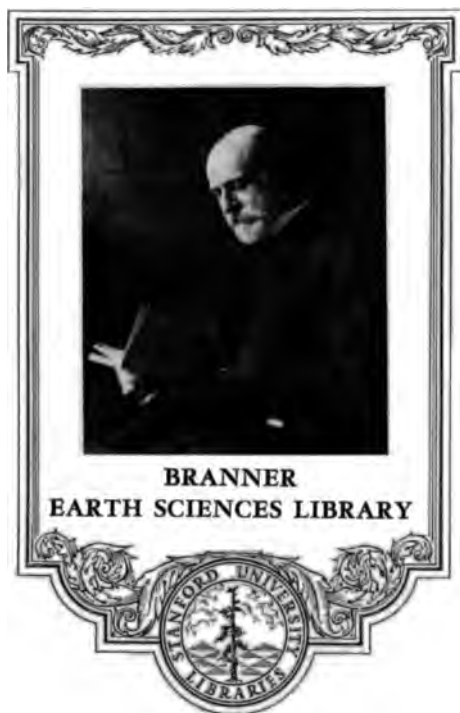
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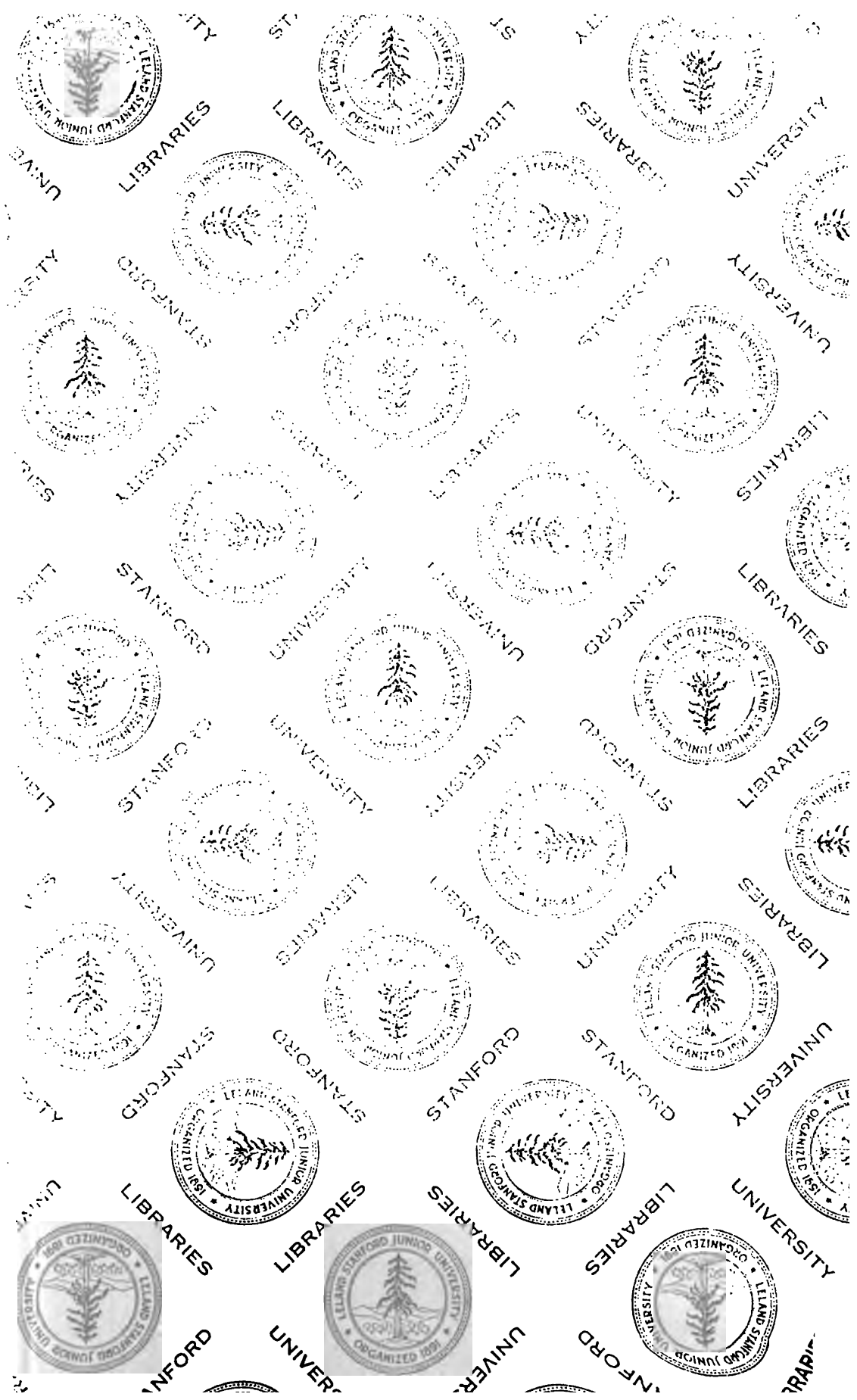
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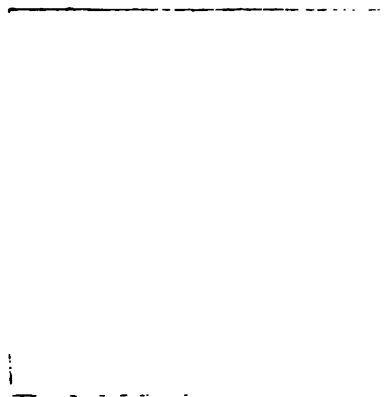
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**THE BUILDING AND ORNAMENTAL STONES
OF NORTH CAROLINA**

BY

THOMAS L. WATSON AND FRANCIS B. LANEY

WITH THE COLLABORATION OF

GEORGE P. MERRILL

NORTH CAROLINA GEOLOGICAL SURVEY

JOSEPH HYDE PRATT, STATE GEOLOGIST

BULLETIN NO. 2

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UNIVERSITY OF NORTH CAROLINA

RALEIGH

E. M. UZZELL, PUBLIC PRINTER

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LETTER OF TRANSMITTAL

CHAPEL HILL, N. C., April 1, 1906.

To His Excellency, HON. R. B. GLENN,
Governor of North Carolina.

Sir—I have the honor to submit for publication as Bulletin 2 of the Reports of the North Carolina Geological Survey, a description of the Building and Ornamental Stones of North Carolina, which has been prepared by Professor Thomas L. Watson, of the Virginia Polytechnique Institute, Blacksburg, Va., and Mr. Francis B. Laney, of the Survey, with the collaboration of Mr. Geo. P. Merrill, Curator of the National Museum, Washington, D. C.

This bulletin is intended to call attention to the economic value of the stone deposits in the State that are suitable for building and ornamental purposes. North Carolina is well supplied with stone that is adapted to all kinds of building purposes, and its geographic position renders it easily accessible to the markets of our largest cities for building stone.

With great respect,

Yours obediently,

JOSEPH HYDE PRATT,
State Geologist.

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PREFACE

The following report on the Building and Ornamental Stones of North Carolina is not claimed to be either exhaustive or final; but has been published at the present time in order to call attention to the economic value of the building stones of North Carolina, their location and their commercial possibilities. The evidence at hand shows the State to be well supplied with a great variety of building stone materials, particularly those of a granitic type. With perhaps the possible exception of Georgia, it is better supplied both as regards quality and variety than any of the other Appalachian States south of New England. This is an important fact and taken in connection with the mildness of the climate, which permits a long season of outdoor labor, and the cheapness of labor itself, should result in the development of a very extensive industry.

The field work for this report was done by Dr. Thomas L. Watson and Mr. Francis B. Laney, commencing during the summer of 1903. Mr. Laney began work the latter part of May, 1903, and continued either in the office or the field until the end of January, 1904. There was no further field work done until the summer of 1905, when Mr. Laney spent a portion of the summer in the field, visiting a few areas and re-visiting some of the more important quarries that had been studied in 1903, noting further development and additional equipment. Thus the report presents the status of the stone industry of the State at the beginning of July, 1905.

Dr. Watson entered the field early in June, 1903, and finished soon after the first of September. He continued his studies, however, on the petrography of the granites and gneisses, and all the petrographic work, together with a large portion of the manuscript relating to the siliceous crystalline rocks, has been prepared by him. The field work, as far as possible, was divided, Mr. Laney devoting the larger part of his time to the marbles, sandstones, serpentines, and road materials; while Dr. Watson worked almost exclusively on the granites and gneisses, with incidental reference to the associated eruptives, the diorites, diabases, and gabbros. In connection with this, he was assisted for a period of six

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Acknowledgments are also due to The North Carolina Granite Corporation, of Mt. Airy, for valuable information and many courtesies; to the Balfour Quarry Company, of Asheville, for personal assistance, information, etc.; to Mr. D. A. McDonald and Col. A. H. McNeill, of Carthage, for assistance and information regarding the sandstones of Moore County.

JOSEPH HYDE PRATT,
State Geologist.

weeks by Mr. Laney, who visited the more remote regions of the State and those localities most difficult of access. Dr. Merrill was only able to make five trips into the field, principally in the summers of 1903 and 1905, and, on account of other duties, was obliged to content himself with going over somewhat hastily such areas visited by the others; especially those which afforded an opportunity for differences of opinion. In all instances he found the opinions expressed safe and the work well and conscientiously done.

In connection with this investigation on the building stones, there have been but few tests made to ascertain resistance to crushing, shearing, elasticity, or absorption, chiefly because the present bulletin is a preliminary report calling attention to the deposits of stone, especially those of known economic importance, and indicating how these can be opened and operated profitably. There have been a few tests made with a view to ascertaining the possible loss of strength of sandstone through absorption of water and freezing, which are given on pages 235-6. No chemical analyses were attempted, nor were they for the most part considered essential for the work at hand, as Dr. Merrill still adheres to his opinion that pressure tests in themselves alone are of little value and that more can be learned from an examination in the field than through all known laboratory tests taken together. Many of the chemical analyses that have been used were taken from the First Biennial Report of the North Carolina Geological Survey,¹ which contains a short paper by Professor J. V. Lewis on the Building and Ornamental Stones of the State.

In the preparation of the maps for this report, the resources of the United States Geological Survey were drawn upon whenever possible, the work of Mr. Arthur Keith proving especially valuable. The tests of road materials were made under the direction of Mr. Logan Waller Page, of the Department of Agriculture, and those for resistance to crushing by Mr. H. S. Betts, of the Bureau of Forestry. The photographs of the crushed cubes were kindly furnished by Mr. B. J. Howard, the Microscopist of the same department.

The field of investigation covered by this report has been touched upon by various workers, beginning with Dennison Olmstead in 1824. The most important investigations that have been made, however, were those by Professors W. C. Kerr and J. Volney Lewis. Appropriate references to the writings of these gentlemen are made in the text.

¹ First Biennial Report, N. C. Geological Survey, 1891, pp. 61-103.

Acknowledgments are also due to The North Carolina Granite Corporation, of Mt. Airy, for valuable information and many courtesies; to the Balfour Quarry Company, of Asheville, for personal assistance, information, etc.; to Mr. D. A. McDonald and Col. A. H. McNeill, of Carthage, for assistance and information regarding the sandstones of Moore County.

JOSEPH HYDE PRATT,
State Geologist.



GRANITE QUARRIES, MT. AIRY, SURRY COUNTY, N. C.



GRANITE QUARRIES, MT. AIRY, SURRY COUNTY, N. C.

navigable rivers, naturally had a great advantage, but the rapid increase of railroad facilities has largely done away with this, and extensive and important quarries are now worked far inland and remote from water transportation.

Naturally, a stone for use in any but rough construction must work freely and safely. There is a greater difference in stones, even of the same kind, in this respect than is ordinarily supposed. As a rule, the granitic and trappean rocks are the most expensive to work, but the rule is by no means without exception, since much depends upon the degree of development of those properties common to nearly all stones, of breaking with comparative ease along two directions at right angles with each other and known as rift and grain. The rift is, as a rule, horizontal or parallel to the original bedding of the stone, if such it may have had; the grain is less perfect than the rift, is at right angles to it and in a vertical direction. Stones in which these qualities are well-developed can often be worked more economically than others which may be softer. In a general way, a stone of fine and even grain will be found to work more readily than one that is coarse. The same is true of its weathering qualities. A stone which is a mixture of hard and soft particles is rarely suitable for polished or finely finished work. Veined stones, on account of the differing character of the vein matter and that composing the bulk of the rock, often work with great difficulty, the veins proving, moreover, sources of great weakness, though such may add variety and beauty to the stone.

The colors found in stone are mainly the quiet tones. Among granites the grays preponderate, though pink and red varieties occur; among marbles pure white, through blue-gray, to black; pink, yellow, and red colors are also found. Among sandstones the gray, buff, brown, and red-brown are most common. The suitability of any particular color is largely a matter of taste and, as such, need not be discussed here.

The matter of color of a rock, when first quarried, after prolonged exposure, and after working, is one that should, however, be considered in some detail. Among siliceous crystalline rocks the colors are due mainly to the presence of colored minerals or to the physical condition of the feldspars. Thus, the gray color of granites is due largely to an admixture of white feldspars and black mica or hornblende; the red colors to red feldspars; the dark greenish, sometimes almost black colors to clear, pellucid feldspars; and the white, to white feldspar. The dark colors of the diabases and the gabbros are due to the pellucid feldspars and the dark pyroxenes they carry. Pure limestones and dolomites are white simply because that is the color of the calcite or dolomite which

forms their chief constituent. The dark color common in this class of rocks is due to the presence of carbonaceous matter; the red to iron oxide, though the pink and red colors of some of the onyx marbles seems to be due, in part, also to organic matter. The red, brown, and yellow colors of sandstones are due to iron oxides. The changes in color which these rocks are likely to undergo on exposure are noted in the remarks on rock weathering. It may not be out of place to state here, however, that nearly any feldspathic rock is likely to become lighter in color during the incipient stages of weathering, owing to the opening up of the cleavage planes in the feldspars. It is for this same reason that the hammered surface of a rock of this type is of a lighter color than the natural rock face or polished surface. The impact of the hammer breaks up the granules on the immediate surface, not, it may be to the point of immediate disintegration, but enough so that the light falling upon the surface is reflected, instead of absorbed, and the resultant effect upon the eye is that of whiteness. The darker color of a polished surface is due merely to the fact that, through careful grinding, all these irregularities and reflecting surfaces are removed, the light penetrates the stone, is absorbed, and the effect upon the eye is that of a more or less complete absence of light, or darkness. Obviously then, the more transparent the feldspars and the greater the abundance of dark minerals, the greater will be the contrast between hammered and polished surfaces. This is a matter worthy of consideration in cases where it is wished, as in a monument, to have a polished die, surrounded by a margin of hammered work to give contrast. Often, when a piece of work of this nature is exposed, the contrast between hammered and polished work diminishes slightly, owing to the gradual weathering out of the particles splintered through hammering. The contrast is less when the stone is wet than when dry, because the water fills all the little rifts and crevices and, by its refracting power, tends to produce the same effect as though the stone were polished.

SURFACE FEATURES OF THE STATE.

The State of North Carolina, considered with reference to its surface features—its physiography, as it is ordinarily termed—may be divided into three parts: A western or mountain region; a central, submontaine or plateau region, usually designated as the Piedmont plateau region and an eastern plains region, usually designated as the coastal plain region.

The first includes the rugged mountainous area extending from the State line eastward, to, and including the Blue Ridge. The second or

submontaine region, known to geologists as the Piedmont plateau, occupies the central portion of the State, and extends from the Blue Ridge to a line which may be drawn from the western end of Northampton County on the north, through Richmond County on the south, to the State line. The third, or coastal plain region, extends from the Piedmont border eastward to the coast. It comprises an area of nearly two-fifths of the entire State and is characterized by loosely consolidated sands, gravels, and marls which need little consideration from the present standpoint. The central and western portions of the State, which include the Piedmont and mountain areas, are greatly diversified and abound in a variety of useful building-stone material.

Roughly speaking, the geological formations which are capable of yielding desirable stone for structural purposes or ornamentation traverse this part of the State in northeast and southwest directions. Beginning at the western margin of the coastal plain, there is found extending northeast from Raleigh a broad belt of gneissic rocks, succeeded on the west by one of brown sandstone, and this in order by belts of schist, granites, and gneisses, to the State line, the last mentioned belt carrying in Cherokee, Graham, and Swain counties a narrow belt of marble. There are numerous minor exceptions to the regular order as given above, which will be noted later.

GEOGRAPHIC POSITION OF THE STATE CONSIDERED WITH REFERENCE TO OTHER THAN LOCAL MARKETS.

The State of North Carolina, as described by Prof. W. C. Kerr, is situated on the Atlantic Slope of the Appalachian Mountains, in the middle latitude of the United States and halfway between Lake Erie and the Gulf of Mexico, being included very nearly between the parallels 34° and $36\frac{1}{2}^{\circ}$ north latitude, and between the meridians $75\frac{1}{2}^{\circ}$ and $84\frac{1}{2}^{\circ}$ west longitude, and extending from the sea coast to the crest of the Smoky Mountains. The extreme length of the State is more than 500 miles, and greatest width 188 miles; its area 52,286 square miles, of which the eastern 20,000 square miles is included in the area referred to in the previous chapter as the coastal plain, a region fairly level and unbroken by eminences of any importance. The central portion of the State is a submontaine plateau with an average elevation above sea-level of some 1,000 feet. The western portion, as already noted, is mountainous. No navigable streams traverse the State, and except in the eastern sections, transportation is necessarily limited to railways.

To appreciate in full the bearing of these facts upon the subject in

hand, there is given here, in part, what has been elsewhere stated regarding this same subject.¹

"The majority of stones used for any form of structural or decorative work may be roughly classed under three heads: (1) The crystalline siliceous rocks, including the granites, gneisses and diabases, or trap-rocks; (2) the calcareous rocks, including all limestones and dolomites, both the crystalline and compact common varieties; and (3) the fragmental or clastic rocks, including the sandstone and clay slates. Those of the first group result either as erupted molten matter from the earth's interior or from the metamorphism of siliceous sediments. Those of the second group originate mainly as deposits of calcareous mud from the breaking up of shells, corals, and the remains of other marine animals on an old sea bottom. Those of the third group result from the breaking up of older rocks, and the accumulation on the bottom of lakes and seas of the resultant sand, clay, or mud in beds of varying thickness, to be subsequently hardened into stone.

"Now the essential difference between a marble and a compact common limestone, like those of Ohio or Kansas, is that the first has undergone, through the combined action of heat and pressure, just the right degree of change, or metamorphism as it is technically called, to develop in it crystallization and color; the essential difference between a brick or fire clay and a cleavable slate suitable for roofing, is, as explained elsewhere, that the first named still retains its plastic condition as it was laid down in the form of fine silt on a sea bottom, while the slate has by geological agencies, by actual movements of the earth's crust, been so squeezed and compressed as to lose all resemblance to its former self, and become the cleavable article of commerce we now find it.

"These processes of change, as noted above, are dependent very largely upon the actual movements, warpings and foldings as one might say, of the earth's crust and the heat and chemical action which is thereby generated, and since these movements take place only with extreme slowness, whole geologic ages being occupied in their inception and completion, it follows as a matter of course that these metamorphic rocks, these gneisses, marbles and roofing slates, are found only among the older rocks and only in those portions of the country where this crust has been warped, compressed, and folded as in the process of mountain making. In other words, one need expect to find these rocks in their best development only in States bordering along more or less extensive mountain ranges, while in the great interior plains and prairie regions they will

¹ George P. Merrill, *Stones for Building and Decoration*, Wiley & Sons, N. Y., 1903.

be comparatively rare. It is of course probable, and perhaps may be regarded as a matter of certainty, that at great depths beneath the land surface in this interior region are to be found the Archæan gneisses which seem to form the floor of the continent, and possibly other rocks metamorphosed by the heat and pressure of great depths. Being, however, covered by many feet of later deposits, they may, for our purposes, be left out of consideration. Let us then consider the physical features of the earth's crust as found within the limits of the United States, and discuss briefly the various rocks so far as they are dependent upon or controlled by these features.

"Let one take a map of the United States and draw a straight line from a point near Montreal, Canada, to the middle of Alabama. East of this line will lie the entire Appalachian Mountain system and with a few exceptions the States traversed by or bordering upon this system are the only States east of the Rocky Mountains containing granites, gneisses, diabases, crystalline calcareous rocks (marbles) or roofing slates. These exceptions are to be found in northern Wisconsin; in Minnesota, west of Minneapolis; in small areas in southeastern Missouri, principally in Iron, Masidon, and St. Francois counties; the Black Hills in South Dakota; in a small area near Little Rock, Arkansas, and in a few small isolated areas in the Indian Territory and eastern Texas, as in Burnet County. The whole interior of the country, comprising all but the extreme eastern portions of West Virginia, Kentucky, and Tennessee; all of Ohio, Indiana, Illinois, Iowa, Nebraska, the Dakotas, Kansas, Mississippi, Louisiana, Florida, Oklahoma, and with the exceptions above noted, all of Missouri, Arkansas, and eastern Texas, though containing sandstones and limestones of the common and oölitic types, produce neither granite, gneiss, trap-rocks, nor slates, nor, except in small quantities, anything that can be called a marble. The earth's crust throughout this entire area has been little changed or disturbed by the eruption of molten rocks or by the processes of mountain making. The sedimentary rocks remain little altered, or if metamorphosed, they have been, and still remain, covered by later deposits.

"It does not necessarily follow, however, that all the rocks east of this line, as drawn above, have undergone metamorphism. On the contrary, there remain many areas of rock little changed, and in some cases it is possible to trace beds of unaltered limestone till they pass into the pure white marble. It has thus been shown that the pure white statuary marble of Carrara, Italy, was once a common fossiliferous limestone, but which has become converted into marble by the heat and pressure incident to the formation of the Apennine Mountains.



FIG. 1.—Map showing the favorable position of North Carolina relative to markets for building stones.

is said to be porphyritic and the porphyritic minerals are themselves referred to as phenocrysts.

Color.—The color of the granites is usually some shade of gray, though pink or red varieties are not uncommon. The colors are dependent largely upon the relative abundance of the mica and the character of the feldspars. Those granites containing a large proportion of black mica are naturally of a darker gray color than those containing but little. The pink and red colors are due to the presence of pink and red feldspars.

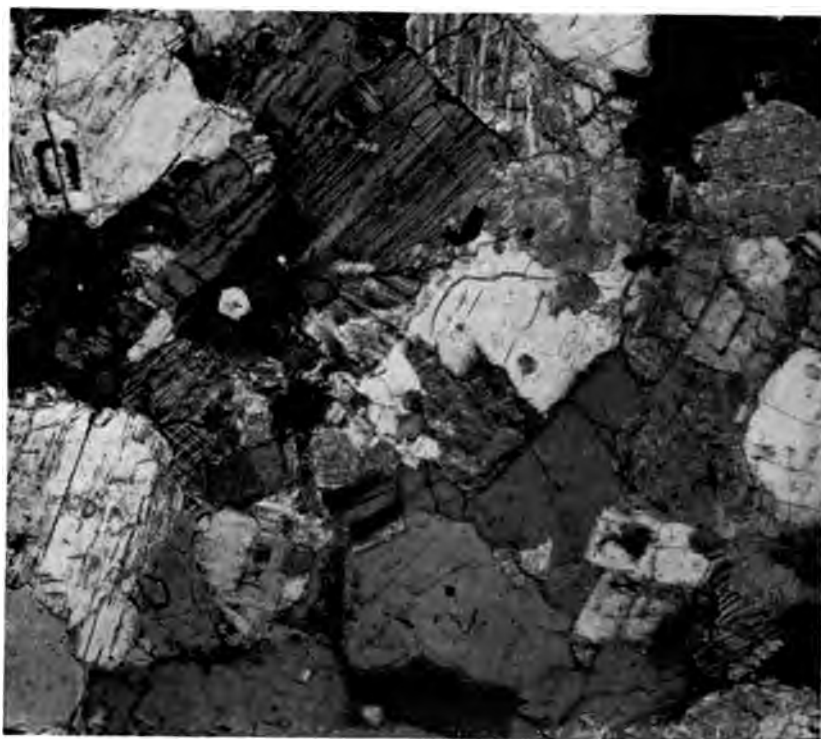
Weathering Qualities.—When exposed in the walls of a building, granites are susceptible to unfavorable changes mainly through disintegration by expansion and contraction of the constituent minerals, as already noted on page 3. Being composed almost wholly of siliceous minerals, chemical agencies, such as solution and oxidation, are as a rule of minor importance. In some instances the rocks contain pyrite which oxidizes and stains the stone an unsightly rusty color. More rarely the black mica undergoes decomposition, though this occurs only after many years exposure. The disintegration through heat and frost usually manifests itself first on the feldspars, which split up, or at least separate into thin foliæ along the lines of cleavage, to which reference has already been made. The separation between two cleavage laminae may be but a thousandth of an inch, but as it allows the penetration of moisture from rains such a change renders the stone susceptible to the unfavorable action of frost. The black mica is susceptible to the same changes, and its presence in too great profusion is a detriment, rendering the stone weaker, more difficult to polish, and not likely to retain its lustre when once polished.

Since then the preliminary stages of decomposition in granites are those of disintegration, it is evident that a rock in which the particles are closely dovetailed or interknit will be more lasting than one of a granular structure (see Pls. IV and V).

In connection with the granites, it is necessary to consider also certain rocks of the same mineral composition but differing in that they possess a banded or foliated structure due to the arrangement of their constituent minerals in more or less parallel bands, or foliæ. Such rocks are known as gneisses, or sometimes by the quarrymen as bastard granites.

On account of the parallel arrangement of the minerals, the gneisses work very unevenly in different directions and cannot be utilized for high grade, finely dressed work. For massive masonry, bridge abutments, they are often, however, fully equal to the granites.

Under the name of *black granite*, and *trap*, it is customary to include a series of igneous rocks, occurring mostly in the form of dikes, which



A. MICRO-STRUCTURE OF GRANITE, MT. AIRY, SURRY COUNTY.



B. MICRO-STRUCTURE OF GABBRO, BARBER JUUNCTION, ROWAN COUNTY.

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differ widely from the granites in their mineral composition, containing neither quartz nor orthoclase feldspar, but consisting essentially of plagioclase feldspar and the minerals augite, hornblende, and sometimes olivine and mica. Such are properly classed as gabbros, diabases, diorites, etc. The working qualities of these rocks are as a rule much inferior to the granites, and their colors much too sombre for any but monumental purposes, and for road construction.

The rock at Barber junction on the Southern Railway 12 miles northwest of Salisbury is a good example of the better class of these rocks (see p. 119).

Quarrying and Working.—Stones of the granitic type can be economically quarried only with the use of powder, the freed blocks being afterward worked up by plug and feather splitting, and by hand hammers and chisels. The great hardness of the material largely precludes the use of steam channellers or of saws for cutting it into blocks and slabs, as is done with marbles and many sandstones. Fortunately the great toughness of the rock renders it only remotely liable to injury through blasting. Machines have been invented and are in use for planing, polishing, and even turning columns of granite in some of the large eastern works, but such as yet have scarcely been introduced into North Carolina.

Uses.—The granites are among the strongest, most massive and durable of natural building materials, and all things considered, are perhaps better adapted to a wider range of structural and ornamental uses than any other stones. The crushing strength of rocks of this type varies as a rule from 15,000 to 25,000 pounds, as shown in the table on p. 156. These figures are so far beyond anything demanded in ordinary structures that this feature can be safely ignored. The colors are as a rule cold, but the appearance of strength which such impart to a building will always render them desirable, particularly in massive structures. The introduction of machinery into stone working, moreover, renders possible the production of polished surfaces for columns, pilasters, and wainscotings. Being massive throughout, without rift or grain developed sufficiently conspicuous to be detected by the ordinary observer, the granites are eminently adapted for columns, monuments, and other structural forms that are to be viewed from all sides, and in which, as a consequence, bedding lines, or other blemishes would be unsightly.

GEOGRAPHIC DISTRIBUTION OF THE GRANITES, GNEISSES, AND ASSOCIATED CRYSTALLINE ROCKS.

Introduction.—The granites of North Carolina are distributed over about one-half the total area of the State, but the productive part of

this area is considerably less. Openings from which more or less granite has been quarried in the past have been made in a majority of the counties in which granites occur, but at the present time less than a dozen quarries are being systematically worked. The quarries in active operation during the summer of 1905 were confined principally to three areas, namely, the Greystone-Middleburgh area in Vance County; the Dunn's Mountain area, including the quarries in the vicinity of Faith Post-Office, in Rowan County; and the Mount Airy quarries in Surry County. Numerous smaller quarries were worked somewhat irregularly during the summer in many localities over the State, principally to supply crushed stone for macadam on the streets and roads in the various towns and counties.

Geographically, the distribution of the granites and gneisses is into the three larger physiographic provinces of the State, namely, the coastal plain, the Piedmont plateau, and the Appalachian Mountains. The larger part of the granites, however, are comprised within the limits of the Piedmont plateau region. Smaller workable areas of massive granites, usually of excellent grade, are distributed through a number of counties along the inner margin of the coastal plain. The large areas of granite rocks distributed over the mountain region are usually schistose in structure and seem less desirable for certain high grades of work in which granites are used. The distribution of the granites and gneisses in the State is indicated on the map, Pl. VI.

Geologically the Piedmont region is divided into a number of belts, which, with one exception, contain larger or smaller areas of granitic rocks. For convenience of description the general area in the State containing granites and gneisses may be divided into the following belts, the location of which is indicated on the accompanying map¹ (Pl. III).

I. The Coastal Plain Region.

II. The Piedmont Plateau Region.

- (1) The Northeastern Carolina Granite Belt.
- (2) The Carolina Metamorphic Slate and Volcanic Belt.
- (3) The Carolina Igneous Belt. (The Main Granite Belt.)
- (4) The Western Piedmont Gneiss and Granite Belt.

III. The Appalachian Mountain Region.

It will be observed that this division of the State into belts is essen-

¹ Kerr, W. C., *Geology of North Carolina*, 1875, Vol. I; and accompanying map. See, also maps accompanying the subsequent reports of the North Carolina Geological Survey.

differ widely from the granites in their mineral composition, containing neither quartz nor orthoclase feldspar, but consisting essentially of plagioclase feldspar and the minerals augite, hornblende, and sometimes olivine and mica. Such are properly classed as gabbros, diabases, diorites, etc. The working qualities of these rocks are as a rule much inferior to the granites, and their colors much too sombre for any but monumental purposes, and for road construction.

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- LEWIS, J. V., *Notes on Building and Ornamental Stones.* First Biennial Report of the State Geologist. North Carolina Geological Survey, 1891-'92 (1893), pp. 57-107; for granites and gneisses see especially pp. 75-95.
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- PRATT, JOSEPH HYDE, *The Mining Industry in North Carolina for 1901, 1902, 1903, and 1904*; see pp. 76, 18, 54, and 68 respectively for granites.

The authors have not had access to all of the earlier reports of the North Carolina Survey, but many of the later ones, particularly those relating to the ore-deposits, incidentally contain some mention of the rocks in the State that are of economic importance.⁴ Such other references as have been published on individual areas in the State are made in their proper place in the body of the text.

² Maps published by N. C. Survey from 1891 to date; and Kerr, W. C., Report for 1875, Vol. I.

³ Bulletin No. 3, N. C. Geol. Survey, 1896.

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green color to the rock and it would be properly designated a greenstone-schist. Where best exposed such rocks strongly suggest derivation from an altered basic igneous rock, probably diorite or diabase. Perhaps the best exposures, though considerably weathered, are found in Richmond County in and around Rockingham, the county-seat. Partially weathered outcrops of the rock are exposed in the street across from the station at Rockingham.

The granites are massive biotite rocks varying from fine even-granular to coarse porphyritic in texture and from gray to pink in color. Jointing is usually well developed in the granites intersecting the rock in three general directions, namely, northwest, northeast, and north-south. The granites are younger than the schists and gneisses into which they have been intruded, as evidenced by the nature of the few contacts in the partial decay of the rocks and by their massive structure as contrasted with the completely schistose structure of the surrounding rocks.

Very many dikes of basic composition, largely diabase, penetrate the crystalline rocks of the various areas in the coastal plain. The dikes vary from 10 to 140 feet in width and they strike in two principal directions, northwest and north-south, with most of them cutting in the northwest quadrant. They are younger in age than the Newark sandstone which they cut and are older than the coastal plain formations which would indicate middle or late Mesozoic age. Petrographic description of the rocks is given below under the description of the individual areas, which are taken up by counties.

ANSON AND RICHMOND COUNTIES.

THE WADESBORO-ROCKINGHAM GRANITE AREA.

The Wadesboro-Rockingham granite area has an east-west extension of approximately 14 miles, located partly in Richmond and partly in Anson counties. The easternmost outcrops of the granite are exposed about 2 miles west of Rockingham, along the Steele cotton mill road, only a short distance south of the Seaboard Air Line Railway. It is traced westward from this point for a distance of about 14 miles or approximately 3 miles east of Wadesboro. East about one mile from the western exposure of the granite, the Triassic sandstones first appear overlying unconformably the crystalline schists. The intervening area between the granite and the sandstone is composed of crystalline schists of variable mineral composition ranging from micaceous to quartz schists which pass westward beneath the sandstones. Most of the area between Rockingham and the first outcrops of the granite to the west, is covered

by the coastal plain sands, affording but slight evidence of the nature of the underlying crystalline rocks in contact on the east side with the granite. In and about the town of Rockingham the principal outcrops are of greenstone-schist, always much crushed and fractured and thinly schistose. No fresh material could be obtained of the rock but the weathered outcrops strongly indicate derivation from an original basic igneous rock. The schists both to the east and west of the granite mass must be regarded as older in age than the granite and forming the country rock into which the granite was intruded.

The northern part of the area is crossed by the main line of the Seaboard Air Line Railway in an east-west direction and it is again crossed in a north-south direction by the Pee Dee River, which forms the dividing line between Richmond and Anson counties. The largest part of the area, however, extends southward from the railroad and west from the Pee Dee River. Irregular patches and stretches of the coastal plain sands cover the granite over many of its parts. Outcrops of the hard and firm, fairly fresh granite are rather numerous, largely in the nature of huge boulders, ledges, and flat-surface masses, the latter containing several acres of surface in the largest exposures. Exposures of the granite in both the weathered and the fresh condition are seen to advantage in the cuts at many points along the Seaboard Air Line Railway.

Immense boulder and ledge exposures of the granite occur $2\frac{1}{2}$ to 3 miles west of Rockingham along the Steele cotton mill road at Spring Branch near the picnic grounds. Extensive exposures of the same nature occur over the hill-slope and in the railroad cut at the foot of the hill where Hitchcock's Creek is crossed by the railroad. The granite is extensively exposed in the vicinity of Lilesville, 5 miles east of Wadesboro, in the cuts along the Seaboard Air Line Railway, and back from the railroad as flat-surface masses and large boulders. About one-quarter of a mile north of Lilesville flat-surface masses of the granite are exposed over a considerable area on the two sides of a small stream. Approximately $2\frac{1}{2}$ miles south of Wadesboro is a flat-surface exposure of the granite of more than an acre in extent, locally known as "flat-rock." The exposure has a gentle southward slope of about five degrees which ends abruptly in a face of 8 to 10 feet.

In all the outcrops observed the rock is fairly uniform in both color and texture. It is coarse-textured, porphyritic biotite granite of a decided pinkish-gray color, tinged a delicate yellowish-green color which becomes stronger in some places than in others. The rock derives its gray color from the presence of black biotite, while the pink and yellow tints are imparted by the abundance of feldspars of those shades. Over most



A. WEATHERED GRANITE IN RAILROAD CUT WEST OF LILESVILLE, ANSON COUNTY.



B. DECOMPOSED DIABASE DIKE IN PORPHYRITIC GRANITE, LILESVILLE, ANSON COUNTY.



A. WEATHERED GRANITE IN RAILROAD CUT WEST OF LILESVILLE, ANSON COUNTY.



B. DECOMPOSED DIABASE DIKE IN PORPHYRITIC GRANITE, LILESVILLE, ANSON COUNTY.

A thin section of similar rock exposed in the Seaboard Air Line Railway cut, one mile west of Lilesville, is identical under the microscope with that described above, except that no microcline occurs in the rock near Lilesville.

DIKES OF BASIC INTRUSIVE ROCKS IN THE ROCKINGHAM-WADESBORO
CRYSTALLINE AREA.

From Rockingham to Wadesboro the crystalline area is penetrated by dikes of basic igneous rocks which vary in width from a few feet to several hundred feet. Within the western limits of the town of Rockingham at the Great Falls cotton mill is a much crushed and otherwise altered though massive diabase dike striking N.-S. and more than 100 feet wide. The rock is dense and hard and considerably altered, containing large areas of quartz and much epidote. It is of a pronounced greenish color imparted by the alteration products and would be properly designated a greenstone. In the construction of the mill-dam it was necessary to do a vast amount of blasting of the rock thereby affording a large and excellent exposure of the dike.

Between 2 and $2\frac{1}{2}$ miles west of Rockingham on the Steele mill road the porphyritic granite is penetrated by a dike of fine-grained nearly black diabase 25 or more feet wide and striking northwest. Three and a half miles west of the same town, one quarter of a mile north of the Steele cotton mills and on the north side of the railroad, the granite is penetrated by a dike of dense, medium-grained, black norite, 300 feet wide and striking N.-S. A small opening was made in the dike at this locality some years ago and a few stones were obtained for use in the piers of the railroad bridge across Pee Dee River. Results of tests of this rock for road material are given on p. 266.

In a cut along the Seaboard Air Line Railway, $1\frac{1}{4}$ miles east of Lilesville, a dike of medium-grained diabase, nearly black in color, 140 feet wide, striking N. 20° W., cuts the porphyritic granite. None of the fresh granite is exposed in the railroad cut at this point but it can easily be identified by its characteristic decay (Pl. IV, B). West of this dike about $\frac{1}{4}$ of a mile and near the 129 mile-post on the railroad is a second dike of similar character penetrating the granite, and is 25 feet across.

There are two parallel diabase dikes near together and not exceeding 10 feet in width and striking N. 20° W. and cutting the granite, 3 miles east of Wadesboro, on the Lilesville-Wadesboro Road and three-quarters of a mile south of the railroad. About one-quarter of a mile further



A. RESIDUAL DECAY DERIVED FROM THE WEATHERING OF PORPHYRITIC GRANITE, 1 MILE WEST OF LILESVILLE, ANSON COUNTY.



B. GRANITE DIKE PENETRATING DECAYED ROCK, 1 MILE WEST OF WOODLEAF, ROWAN COUNTY.

west on the same road, a similar dike but wider and striking N. 20° W., is exposed in front of Mrs. Bennett's residence.

From this point west to Wadesboro and beyond for some miles, dikes of diabase become more numerous, penetrating the Triassic sandstones. Not less than 40 of these dikes have been observed within these limits on which careful observations were made and specimens collected from the more important ones. The variation in strike is from N. 10°-35° W., with the same variation in width noted as those penetrating the crystalline rocks described above and to the east of the sandstone area. The texture ranges from medium- to fine-grained and they are uniformly hard and dense black rocks.

The dikes mentioned above comprise only some of the more important ones cutting the crystalline rocks in Richmond and Anson counties. With possibly one or two exceptions, the dikes penetrating the area are of late Triassic age, as they are found intersecting both the crystallines and the sandstones, whose age in the latter case is Triassic.

WILSON COUNTY.

Introductory Statement.—Small areas of crystalline rocks are exposed at only a few places in Wilson County. With these few exceptions, the entire County is covered by the sediments of the coastal plain formation. Only two of the crystalline areas are known to contain workable granites, namely, 3 miles south of Wilson, the county-seat, at the crossing of Contentnea Creek by the Atlantic Coast Line Railway, and extending up stream from this point for a distance of several miles; and 2½ to 3 miles north of Elm City (Toisnot), a station on the Wilmington and Weldon Railroad.

THE CONTENTNEA CREEK GRANITE AREA.

To the south of Wilson, about 3 miles, beginning at the Atlantic Coast Line Railway crossing over Contentnea Creek, granite is exposed for a distance of several miles up stream on the two sides of the creek. The granite is exposed as immense boulders along the stream and as flat-surface masses a short distance back from the creek on either side. Exposures of the granite occur at and near Wiggin's mill on Contentnea Creek, 1 to 1½ miles west of the railroad crossing, and they continue for some distance along the stream both above and below the mill.

The granite is a uniformly coarse-grained rock of a pinkish-red color imparted by the predominant feldspathic constituent of the same color. It has a marked porphyritic tendency. The feldspars are in considerable

excess over the other minerals, and the characterizing accessory biotite is only sparingly present, usually not in large enough amount to impart any distinctive color to the rock. The feldspathic constituent in this granite has been estimated by the road material laboratory in Washington, D. C., to amount to 82 per cent, proportioned as follows: Orthoclase, 50 per cent; plagioclase (albite), 32 per cent. Cleavage in the feldspars is typically developed and Carlsbad twinning is the rule. The larger feldspar individuals will measure $1\frac{1}{2}$ to 2 inches long by $\frac{1}{4}$ to $\frac{1}{2}$ inch wide. They are usually flat-tabular in outline, grading into stout nearly equidimensional forms, and are prevailingly pinkish-red in color and highly lustrous.

Quartz is next abundant to feldspar and is of the slightly smoky, dark vitreous variety, distributed as large anhedra through the rock, which contrast sharply with the feldspar. Biotite is in very small shreds and plates, and is only sparingly distributed through the rock.

Microscopical Examination.—Under the microscope, the thin sections show the Wilson granite to be composed essentially of feldspar and quartz, with the former in much the largest amount. These two make up at least 90 per cent of the rock. Plagioclase nearly equals in amount the potash feldspar, which consists mostly of orthoclase though some microcline occurs. Plagioclase is in very large laths, finely striated and corresponds in physical properties to albite. The feldspars are extensively altered to kaolin and muscovite, not a single entirely fresh individual being found in the slides examined. Quartz is in very large grains interlocking with the feldspar and will probably not exceed 15 per cent of the entire rock. Biotite, the chief characterizing accessory, is only sparingly present, and is largely altered to chlorite. Occasional small grains of iron oxide and a few inclusions of prismatic apatite complete the list of accessories.

The weathered surfaces of the granite exposed near the mill on Contentnea Creek are light in color with a very faint pinkish tone. The feldspars are dull and opaque and have lost much of their decided pink color so characteristic of the same constituent in the fresh granite.

A small opening was made some years ago at the Contentnea Creek-Wilmington and Weldon Railroad crossing, in a flat-surface outcrop of the granite. The opening is located so close to the railroad tracks that the quarried blocks could be swung by derricks directly onto the cars from the opening. Very little sap (partially decayed granite) is found on the granite at this exposure but fresh rock begins at the surface. Some of the stone was used by the railroad company in the bridge piers at Contentnea Creek crossing; and also in the walls at the entrance to

Atlantic Coast Line Railway office building at Wilmington, North Carolina. Good specimens were also secured from this opening for the collection of building stones in the State Museum at Raleigh. The opening will probably average 12 feet in depth, is roughly circular in outline and of less than a quarter of an acre in extent. It is not located many feet above the stream level.

Three sets of joints break the rock into polygonal blocks of various dimensions, striking about N.-S., N. 70° W., and N. 50° E., having apparently about equal development. No seams, veins nor segregations cut the granite and no deleterious minerals that would cause discoloration on exposure, such as pyrite, are present. The granite splits readily and it takes a fine polish as indicated by the dressed cubes in the State Museum at Raleigh. Stone of moderate size can be quarried and the granite may prove a desirable one, especially for monumental and ornamental stock. Results of tests of this rock for road material are given on p. 266.

THE ELM CITY GRANITE AREA.

This area includes some 15 to 20 acres of boulder outcrops of a light gray granite, located just across the Edgecombe County line and in the extreme northern part of Wilson County, about one-quarter of a mile east of the Wilmington and Weldon Railroad and 3 miles north of Elm City (Toisnot). One opening has been made which is reported to have been first worked prior to the Civil War. It covers approximately $\frac{1}{2}$ to $\frac{3}{4}$ of an acre in extent and is worked to an average depth of 30 feet. The decay at the top of the opening will average about 6 to 8 feet in depth, deeper than this in some places and considerably less in others. Near the surface the decay consists of a red gritty clay passing at a slight depth into lighter shades and finally grading into the hard firm granite at about the depth mentioned above.

Work was resumed in April, 1903, to supply stone on contract for macadamizing the streets in the town of Wilson. In June, 1903, stone was being quarried for a similar purpose to be used in the town of Goldsboro. It is said to have been previously used somewhat extensively in railroad construction and as curbing and building stone in Wilmington, and also in the foundations of the Post Office building in Raleigh. Results of tests of this rock for road material are given on p. 266.

The granite is light gray in color with a faint pinkish tone imparted by the feldspar. It is medium coarse-grained in texture, firm and compact and exceedingly hard. Biotite is in minute shreds very much smaller than the feldspar and quartz individuals and shows a marked ten-

dency at times to form segregations. It is present in small amount, but it is in quantity considerably over that of the Contentnea Creek red granite in the same County.

Two sets of joints striking N. 80° W., and N. 40° E., cut the granite. A rather pronounced schistose structure is noted in the granite over the quarry floor, striking about north and south. A very fine-grained slightly greenish black dike of amphibolite containing much disseminated pyrite, penetrates the granite in the quarry in an approximately northwest-southeast direction. On the west side of the quarry the dike has a width of about 4 feet but on the east side it thickens up to a cross section measuring nearly 20 feet. It is finely laminated and closely jointed, blocking out in small rhomboidal sections and is penetrated in all directions by ramifying veinlets of white feldspar of scarcely more than knife-edge thickness. The pyrite grains are mashed and squeezed in the direction of the lamination. Quartz veins also cut the granite in a general north-south strike. Two of the veins observed on the west side of the quarry and near the dike are about 12 inches wide and interbanded or wrapped with films of hornblende.

Microscopical Examination.—Microscopic study shows the rock to be a biotite granite through which are scattered occasional partially idiomorphic crystals of compact hornblende. Feldspar preponderates and is composed of the potash varieties with much striated acid plagioclase whose extinction angles measured against the twinning lamellæ correspond to a feldspar of the composition $Ab_{12}An_{1}$. The feldspars are clouded from slight alteration into kaolin and muscovite. Micropoikilitic structure is well developed in some of the larger individuals of the potash feldspar, the inclusions consisting of large microscopic grains of quartz and striated plagioclase without apparent orientation. Quartz forms distinct areas of an interlocking mosaic of smaller grains than the feldspar, through which are scattered occasional feldspar grains and biotite. Biotite is less abundant, forming small plates of brown color and strongly pleochroic, bleached to green on alteration, and is further altered to chlorite. In one slide of the granite several small crystals of compact hornblende with good cleavage development were noted. The principal accessories include zircon, apatite, a little titanite, and ilmenite.

Microscopically, the thin sections of the dike penetrating the granite in the quarry indicate a very fine-grained amphibolite-schist, in which the arrangement into roughly alternating bands of dark green hornblende and quartz is shown. In the hand specimen the fine schistose structure is pronounced and the rock appears to be made up entirely of hornblende with much scattered pyrite.

Hornblende, in irregular elongated shreds, is the predominant mineral. It is strongly pleochroic from deep blue-green to deep brown, only occasional grains of which indicate traces of the two cleavages. Associated with the hornblende is much epidote in small granules forming aggregates. Only one or two shreds of feldspar were noted in the sections. Quartz is next abundant to hornblende. It shows strain shadows resulting from mechanical stresses in the rock and it contains somewhat numerous inclusions of small stout prisms of apatite.

The structural relations of the rocks in the quarry clearly indicate a greater age for the dike than for those dikes of basic rocks penetrating the rocks in the Rockingham-Wadesboro area, for the same period of metamorphism which affected the granite likewise induced the schistose structure in the basic dike rock.

The joint-plane surfaces are slickensided and coated with a thin veneer of a dark green to yellowish green micaceous mineral, probably damourite. Much of a yellowish-green mineral, probably epidote, is observed in the granite in places, an alteration product derived from the biotite.

The working qualities of the granite are not good, which coupled with the rather close jointing and the numerous seams which cut it, render the granite unsuited for general constructional purposes. Dimension stone could only be obtained by careful selection, but the cost of quarrying to supply only this demand would be entirely too great as the waste would be almost excessive. The rock admirably serves the purpose for which it is quarried at present. Results of tests of this rock for road material are given on p. 266.

The usual method of steam drilling and blasting is employed in quarrying the stone. During the summer of 1903 an average force of twenty men were employed in getting out the stone for macadamizing the streets of Goldsboro.

EDGECOMBE AND NASH COUNTIES.

Description of the Granite.—Beginning about one mile north of Rocky Mount in Edgecombe County, boulder outcrops and small flat-surface exposures of granite are traced along Tar River for some distance westward into Nash County. The granite is traced on both sides of the river and is exposed in places in the bed of the river.

Extending in a general west course from Rocky Mount to Springhope in Nash County, a distance of about 20 miles, and thence in a north-south course along the Nash-Franklin County line into Halifax County, is a large but irregular area of crystalline rocks consisting mostly of

chloritic schists, gneiss, and diorite. Abundant quartz veinlets intersect the rocks of this area conforming in part to the schistosity of the enclosing rocks and in part cutting across the schistosity. For many years it has been one of the gold-producing areas in the State.¹

No contacts between the schistose rocks and the granite were noted but it is probable that the granite postdates the schists inasmuch as the latter suggest derivation in part at least from original igneous masses.

At the cotton mill on Tar River, one mile north of Rocky Mount, several small openings were made in the granite some years ago to obtain stone for local use. Four sets of joints cut the rock, breaking it into blocks of various dimensions. The more prominent ones of these sets strike about N.-S., and NE.-SW. The two less conspicuous sets strike N. 30° W., and N. 80° W. These joints cut the granite at distances varying only a few inches apart in some places to many feet apart in other places.

Pegmatite veins, varying from a fraction of one inch to more than 6 inches in width, and composed of pink feldspar and quartz with a very small amount of biotite, intersect the granite. All gradations between those veins containing mostly feldspar to those containing mostly quartz are noted. In some of them the quartz forms a narrow central band in the feldspar of the vein. Some of the veins are banded with a fine-grained granite of the same mineral composition as the main granite mass. A part of these veins are true veins of segregation since they pinch out in the granite mass and the granite can be traced entirely around them. Except in a few places perhaps, the joints or veins do not interfere with stone of large size being quarried.

Several pieces of diabase were scattered over the surface on the north side of the river immediately adjacent to the granite exposures. These were not in place, but they evidently indicate a dike of the basic rock cutting the granite nearby.

The granite is a medium-grained, gray, biotite rock, the feldspars of which have a decided pinkish tone. It differs from the granite quarried 3 miles north of Elm City in the southern part of the County in being massive and not schistose in structure. It is apparently of good quality and should prove a satisfactory stone for general purposes. Most of the exposures are sufficiently large and with sufficient elevation above the water level of the river to admit of workable quarries being opened.

Microscopical Examination.—A thin section of the rock from the openings made on Tar River near the cotton mill, one mile north of Rocky Mount shows, under the microscope, a medium-textured biotite

¹ Nitze, H. B. C., N. C. Geol. Survey, Bulletin No. 3, 1896, p. 24, et seq.

granite, composed of a closely interlocked aggregate of feldspar, quartz, and biotite. Orthoclase and microcline have about equal distribution through the section with but little plagioclase indicated. Much of the quartz occupies distinct areas, forming a fine-grained mosaic between the larger feldspars. Quartz-feldspar areas in the form of micrographic structure are freely distributed through the section. Biotite occurs in the form of irregular shreds and plates of deep brown color and strong pleochroism, containing inclusions and partly altered to chlorite and a little epidote. A few scattered grains of black iron oxide and inclusions of prismatic apatite and zircon complete the list of minerals in the rock.

RÉSUMÉ OF THE GRANITES OF THE COASTAL PLAIN REGION.

Briefly summing up some of the principal points developed in the foregoing description of the individual granite areas of the coastal plain region, it is noted first, that the workable granites are limited to irregular small areas exposed well within the limits of the inner western margin of the coastal plain, by stripping in places of the loose materials belonging to this horizon. The areas capable of producing workable granite are exposed in Anson and Richmond counties along the South Carolina line, and in Wilson, Edgecombe, and Nash counties to the east of Raleigh.

These areas either lie close to or are crossed by the principal lines of railroad in the eastern portion of the State, rendering them easily accessible and providing ample facilities for transportation of the stone. The outcrops are usually large and are so located as to offer advantageous quarry sites.

The granites of the coastal plain region show considerable range in variation of color and texture, from light gray to pink with a very pleasing mixed yellowish and pink appearance in some places in the Wadesboro-Rockingham porphyritic granite area. Variation in texture is from coarse and medium-fine even-granular to coarse porphyritic.

In composition they are all biotite granites, the Elm City area in Wilson and Edgecombe counties containing some additional hornblende. The accessory biotite is but scantily developed in the Contentnea Creek pink granite in Wilson County, a circumstance which taken in connection with the small size of the biotite shreds, exercises no effect on the color of the rock. Quartz also seems less abundant in the Wilson pink granite than in the other granite areas of the coastal plain. The most noteworthy microscopical feature of the coastal plain granites is the rather large proportion of acid plagioclase in the rock of some of the areas, and it is present in all.

dency at times to form segregations. It is present in small amount, but it is in quantity considerably over that of the Contentnea Creek red granite in the same County.

Two sets of joints striking N. 80° W., and N. 40° E., cut the granite. A rather pronounced schistose structure is noted in the granite over the quarry floor, striking about north and south. A very fine-grained slightly greenish black dike of amphibolite containing much disseminated pyrite, penetrates the granite in the quarry in an approximately northwest-southeast direction. On the west side of the quarry the dike has a width of about 4 feet but on the east side it thickens up to a cross section measuring nearly 20 feet. It is finely laminated and closely jointed, blocking out in small rhomboidal sections and is penetrated in all directions by ramifying veinlets of white feldspar of scarcely more than knife-edge thickness. The pyrite grains are mashed and squeezed in the direction of the lamination. Quartz veins also cut the granite in a general north-south strike. Two of the veins observed on the west side of the quarry and near the dike are about 12 inches wide and interbanded or wrapped with films of hornblende.

Microscopical Examination.—Microscopic study shows the rock to be a biotite granite through which are scattered occasional partially idiomorphic crystals of compact hornblende. Feldspar preponderates and is composed of the potash varieties with much striated acid plagioclase whose extinction angles measured against the twinning lamellæ correspond to a feldspar of the composition $Ab_{12}An_{1}$. The feldspars are clouded from slight alteration into kaolin and muscovite. Micropoikilitic structure is well developed in some of the larger individuals of the potash feldspar, the inclusions consisting of large microscopic grains of quartz and striated plagioclase without apparent orientation. Quartz forms distinct areas of an interlocking mosaic of smaller grains than the feldspar, through which are scattered occasional feldspar grains and biotite. Biotite is less abundant, forming small plates of brown color and strongly pleochroic, bleached to green on alteration, and is further altered to chlorite. In one slide of the granite several small crystals of compact hornblende with good cleavage development were noted. The principal accessories include zircon, apatite, a little titanite, and ilmenite.

Microscopically, the thin sections of the dike penetrating the granite in the quarry indicate a very fine-grained amphibolite-schist, in which the arrangement into roughly alternating bands of dark green hornblende and quartz is shown. In the hand specimen the fine schistose structure is pronounced and the rock appears to be made up entirely of hornblende with much scattered pyrite.

part of the Piedmont region, immediately to the east and north of the northern limits of the belt of Triassic sandstones.

(4) A very wide belt covering the entire western limits of the Piedmont region, composed principally of gneiss and schist with scattered areas of granite and more basic igneous rocks usually in the form of dikes. How much of the gneiss belonging to this area is sedimentary in origin and how much of it is igneous, it is not yet possible to say. That some of the gneisses in this belt, however, are derived from original igneous rock-masses does not admit of reasonable doubt, as developed later in this report in some of the descriptions of the individual areas. The predominant rocks of the belt have been referred to by Professor Kerr as probably Archæan in age.

Recent studies in the different areas of the Piedmont region of North Carolina indicates that the older rocks are penetrated by very many dikes of basic igneous rocks of different types, a part of which are of undoubted Triassic age. Other dikes of the same rock types for reasons elsewhere stated in this report can, with much certainty, be referred to an earlier period of intrusion than that of the Triassic.

It is within the limits of the Piedmont plateau region that the greatest distribution and development of granites and gneisses of commercial importance in North Carolina occur. Considerable variety and abundance of these are noted. The quality in most places is generally excellent; the stone is readily accessible, and, as a rule, it can be easily worked. Numerous quarries have been worked from time to time over many parts of the Plateau region, and so far as the term is applicable the granite industry in the State belongs almost exclusively to this Plateau region.

The granitic rocks of the northeastern area, comprising the counties of Wake, Franklin, Vance, Granville, and Warren; those of the metamorphic slate-schist and volcanic belt; those of the central granite belt, including Mecklenburg, Gaston, Cabarrus, Iredell, Rowan, Davidson, Davie, Forsyth, Guilford, and Alamance counties; and those of the western gneiss belt comprising the counties of Surry, Wilkes, Alleghany, Alexander, and Cleveland, are described below in detail under the four geologic divisions made of the Piedmont region (see maps, Pls. III and VI).

THE NORTHEASTERN CAROLINA GRANITE BELT.

GENERAL CONSIDERATIONS.

The position and limits of this belt are shown on the accompanying map, Plate VI. Its eastern limits mark the line of contact with the coastal plain sediments. On the south the rocks of the area pass be-

neath the coastal plain formations along a line drawn in a general north-west course from near Smithfield in Johnston County, through Wake County to a point about 10 miles west of Raleigh. It is limited on the west by the Triassic sandstones and the so-called metamorphic slate-schist-volcanic belt. It extends northward into Virginia.

The belt includes a whole or a part of Wake, Franklin, Granville, Vance and Warren counties. Granites, gneisses and schists of the mica type, intersected by dikes of basic igneous eruptives, comprise the principal rocks of the area. The granites are, with only a few exceptions, more or less schistose in structure. As a rule, however, the schistosity is not so completely developed as to render the rock unsuited for most uses that the original massive rock might have proved desirable.

Over all parts of the area the rocks are covered by a heavy mantle of residual decay—the result of weathering. Outcrops of the hard and firm, nearly fresh granite, are fairly numerous, however, over most of the belt. The exposures are mostly in the nature of boulder and ledge outcrops along the stream courses and as flat-surface or slightly doming masses away from the streams.

The principal quarries in the belt are those first opened many years ago within the city limits of Raleigh, from which stone was obtained for the State Capitol and other buildings and, for street purposes in the city of Raleigh; and at Greystone and Middleburgh, stations on the Seaboard Air Line Railway, in Vance County. At both Raleigh and Greystone the quarries have been worked at intervals, extending over a long period of years and the openings are quite extensive. More recently numerous smaller openings have been made in many places over the belt to supply a local demand.

WAKE COUNTY.

Most of Wake County is underlaid by granitic rocks, usually deeply decayed. The fresh rocks where exposed are usually schistose in structure, derived in part at least from original massive granites and are true granite-gneisses. Large areas of mica-schist compose the principal rock in places, especially to the west and northwest of Raleigh. The principal exposures in which openings have been made can be grouped and best treated separately under two areas, namely, (a) The Raleigh Granite Area; and (b) The Wyatt-Rolesville Granite Area.

THE RALEIGH GRANITE AREA.

THE CITY QUARRIES.

Within the eastern limits of the city of Raleigh, about $1\frac{1}{2}$ miles from the State-house, and near the Federal Cemetery, two large

BULLETIN NO. 2. PLATE VI





openings from which much stone has been quarried, were first made more than seventy years ago. The records are incomplete and do not afford the exact date of the opening of these quarries. Some stone was quarried prior to 1833 for local use, and from 1833 to 1836 systematic quarrying was done to obtain stone for building the State-house. Work has been resumed at intervals from that time to the present to obtain stone for various purposes, chiefly for paving-blocks and macadam for the streets of Raleigh. During the summer of 1903 a small force was working the larger opening, quarrying blocks for street paving. Two Gates crushers were in operation pulverizing and grading the quarry-waste for road metal and for railroad ballast.

Two openings have been made on the opposite sides (north and south) of the street, with average dimensions as follows: the north opening, which is the largest and principal one, 850 feet long in a north-south direction, 75 feet wide, and worked to a depth of 30 to 35 feet. The south and smaller opening is 330 feet long in a north-south direction, 75 feet wide, and 25 feet deep. As indicated by the size of these openings, the amount of stone quarried from them is very large.

An average depth of about 3 feet of deep red clay derived from the decomposition of the granite is exposed at the top of the openings. The depth of residual clay is greater than 3 feet in some places and less in others. Below this is a zone 10 feet in thickness of less advanced decay, exposing partially decayed granite in thin sheets. Within this zone along the horizontal parting planes and the vertical jointing the rock is broken down into light red granitic clay with the middle portion of the sheets composed of moderately hard though deeply decayed granite. Below this second zone of weathering the granite is a hard, firm and fresh rock to the depth of working.

The rock is a fine-grained, even-textured gray, biotite granite, apparently free from iron sulphides and oxides or other deleterious minerals likely to discolor the stone on exposure. The rock is not entirely massive, but displays more or less of the gneissic or schistose structure in the quarry, secondarily induced by pressure metamorphism.

Microscopical Examination.—Under the microscope the rock is composed, in the order of their abundance, of the principal minerals, feldspar, quartz and biotite. The feldspathic constituent consists of the potash varieties, orthoclase and microcline, with a nearly equal proportion of striated acid plagioclase. Microcline nearly equals orthoclase in amount. Intergrowths of the potash feldspar with plagioclase occur. The large proportion of single individuals of plagioclase in the granite together with the micro-perthite accounts for the excess of soda over the potash

shown in the chemical analysis of the rock, quoted below. Twinning after the Carlsbad law is sometimes observed in the potash feldspar. Overlapping of the periods of crystallization from the magma of the quartz and feldspar is indicated in the rather numerous areas of micrographic intergrowths of these two minerals. In one of the thin sections of the rock micropoikilitic structure is fairly well developed in some of the potash feldspar individuals.

Quartz is of the usual granitic kind. Biotite is distributed through the sections as deep brown and strongly pleochroic shreds largely altered to chlorite. Several shreds of muscovite were noted intergrown with the biotite. Alteration of biotite in one of the thin sections is into a colorless mica and epidote. Zircon and apatite in the form of small prismatic inclusions complete the list of minerals.

Peripheral granulation is shown in fine-grained mosaics of quartz and feldspar filling the interstices between the larger individuals of these two minerals. Further mechanical stress is indicated in the undulous extinction of the quartz and feldspar.

The following analysis¹⁰ indicates to some extent the general chemical composition of the granite from these quarries:

Analysis of granite from City quarry, near Raleigh, N. C.

SiO ₂	69.28
Al ₂ O ₃	17.44
Fe ₂ O ₃	1.08
FeO	1.22
MnO	0.16
MgO	0.27
CaO	2.20
Na ₂ O	3.64
K ₂ O	2.76

Jointing occurs at fairly close intervals but the planes are not sufficiently close to prevent the quarrying of dimension stone. The principal set of joints strikes approximately east and west. The surfaces of the joint-planes are slickensided, coated with a thin veneer of a dull yellow colored mineral, probably damourite.

In the openings the granite is penetrated by very many segregation veins, coarse pegmatite and fine-grained aplite. These cut the granite indiscriminately, although the larger ones are often more or less parallel and conform to an approximate north-south strike. In width the intersecting material varies from a fraction of one inch to, in case of the

¹⁰ Kerr, W. C. *Geology of North Carolina*, 1875, Vol. I, p. 122.

pegmatites, several feet. A single occurrence of a banded aplite-pegmatite was noted, in which the contact was with the enclosing granite on one side and the pegmatite on the other. The pegmatites and segregation veins are similarly composed of coarse crystallizations of feldspar and quartz with occasional biotite. Feldspar predominates and is pink to white opaque in color. Biotite is almost entirely absent from some of the veins but in larger ones it is present in large platy masses distributed oftentimes more or less along the middle portion of the vein.

Since the formation of the veins the granite mass has been subjected to considerable pressure effects, manifested in the folded and crumpled condition of the veins; in slight faulting of the veins resulting in a displacement of as much as six inches in extreme cases; and in the well developed slickensided surfaces of the joint-planes.

Microscopical Examination of the Pegmatite and Aplite.—A microscopic study of a thin section of typical pegmatite from the Raleigh city quarries shows a composition of feldspar and quartz exclusively, with the former greatly in excess. The feldspars are microcline and orthoclase with a slight sprinkling of a striated plagioclase. Microcline is the predominant feldspar which shows micropoikilitic structure in many instances—observed to a less extent in the orthoclase—consisting of quartz and feldspar inclusions. The plagioclase present is mostly as included grains in the potash feldspar. Microperthite occurs sparingly in the thin section. Mica fails entirely, except several pieces of a colorless variety, which is a derived product from the alteration of the feldspar.

Under the microscope a thin section of the aplite appears quite similar to the thin sections of the enclosing granite described above, except that the former is very fine-grained and contains a much smaller proportion of biotite and plagioclase. Microcline and orthoclase are present in nearly equal proportions, with only very little striated plagioclase and microperthite shown. Micropoikilitic structure is developed in some of the potash feldspars and a few small areas of quartz and feldspar intergrowths were noted. The mineral composition of the rock would place it among the potash aplites. Biotite of the same microscopic properties and mode of occurrence as the enclosing granite is only sparingly distributed through the thin section with an occasional intergrown shred of muscovite, and it is much altered to chlorite. Hair-like inclusions of rutile are abundant in some of the quartzes. Iron oxide in minute grains and crystals is sparingly distributed through the slide.

Along the west side of the north opening is a large diorite mass sharply defined from the granite and cut in all directions by pegmatites and

true granite veins, much crumpled and contorted. The pegmatites are largest in the diorite mass and again assume large dimensions on the east side of the quarry in the granite. The line of contact between the granite and the diorite seems to be entirely sharp but exceedingly irregular. The exact relations were not entirely plain but from the nearly continuous exposures of the partially decayed granite over the eastern portion of the city of Raleigh and along the street leading to the quarries of the same general character as that exposed in the quarries, the writer is rather inclined to regard the dioritic mass as intrusive in the granite. More evidence is wanted however to verify this statement. In the west limits of the city and for a distance of at least 3 miles west and northwest the country rock is mica schist highly feldspathic in places, as evidenced by the sections made by the roads and railroads in the rock decay. Fresh rock is seldom exposed.

Microscopical Examination of the Diorite.—Microscopic study of a thin section of this rock from the quarries described above shows it to be a quartz diorite, composed of a large amount of hornblende, plagioclase feldspar, and quartz. Hornblende is deep brown and green with strong absorption indicated for the brown hornblende in which one or more cleavages is well developed. It occurs in irregular elongated forms and contains some inclusions. The deep green hornblende shows only imperfect or no cleavage directions, is only feebly pleochroic, and is an altered form of the brown hornblende. Extinction angles measured against the broad twinning lamellæ of the plagioclase corresponds to labradorite ranging in composition from $Ab_8 An_2$ to $Ab_1 An_9$. A considerable quantity of slightly elongated rounded grains of a colorless non-pleochroic mineral with high index of refraction and strong double refraction is distributed through the slide in association more or less with the hornblende.

When not jointed and cut by the pegmatitic material, the granite is remarkably uniform in texture and color and is a very pleasing and desirable stone; but, as demonstrated in the Capitol building, dimension stone free from the veins cannot be obtained from these quarries. For this reason, the rock where opened at present is not suited for general building purposes, but it is admirably adapted for street purposes in the form of blocks and curbing, into which shapes it can be easily worked.

THE PENITENTIARY QUARRY.

This quarry is located inside the enclosure about $1\frac{1}{2}$ miles west of the Capitol building and was first opened in 1868. The opening is made in a flat-surface exposure of the rock and is roughly circular in

outline having a diameter at the top of from 300 to 350 feet and is reported to have been worked to a depth of 60 or more feet. During the summer of 1903, it was almost filled with water and it had not been worked for many years. This quarry furnished stone for the foundations and walls of the prison building and for various purposes in the city of Raleigh, chiefly for building and curbing.

The rock is an irregularly banded, light to dark gray, biotite granite-gneiss and varies from medium to fine-grained in texture. It is quite variable in composition, containing a large proportion of biotite in some places and correspondingly dark in color, while in others biotite is but sparingly present and the rock becomes a light gray mixture principally of feldspar and quartz. Some of the layers are thick and cannot be distinguished from typical massive granite of the same texture but as a whole the rock mass is finely schistose, the schistosity planes conforming to a general north-south strike.

Two sets of joints of about equal development intersect the rock striking about N.-S., and N. 80° W. For the reason that the opening was nearly filled with water and no immediate adjacent exposures of the granite-gneiss to the opening were noted, further observations were impossible.

THE LEWIS PLACE.

Two miles northwest of Raleigh and about a quarter of a mile west of the public road, are flat-surface and low ledge outcrops of a light gray fine-grained granitic gneiss, occurring on both sides of a tiny stream. Two small openings were made many years ago, one on each side of the stream. The stone quarried is reported to have been used to a small extent in several of the older buildings in Raleigh and for foundations, curbing and flagstone in the same city. The sills and trimmings in Christ Church, Raleigh, are said to have come from this locality.

The rock is a hard siliceous gneiss, containing a minimum amount of biotite disseminated through it in minute shreds. It is thinly schistose, the schistosity conforming to a general N. 10° E. strike. Jointings are not conspicuous in the exposures of the rock, but are spaced rather far apart and belong to a single set striking N. 80° W.

Weathered outcrops of biotite granitic gneiss similar to those described above are observed at several places along the road for a distance of 5 miles northwest of the Lewis place. The country rock is apparently mica-schist, deeply decayed but preserving in the sections of the decay the original schistose structure developed in the fresh rock. The granitic

rocks are plainly younger than the schist, and in the few contacts observed in the partial decay of the two rocks, the granite cuts across the schistosity of the schist.

THE WYATT-ROLESVILLE GRANITE AREA.

The Wyatt-Rolesville granite area is located about 14 miles north of Raleigh and about 4 miles south of Wake Forest, extending east from Wyatt, a station on the Seaboard Air Line Railway, to Rolesville, a distance of about 5 miles. Flat-surface outcrops of several acres in extent are exposed in the vicinity of Wyatt Station and again to the east near Rolesville. As indicated below, the granites of this area are biotite-bearing but differ in some respects from those to the south in the Raleigh area.

WYATT STATION.

From one-half to one-quarter of a miles west of Wyatt's, a flag stop on the Seaboard Air Line Railway, flat-surface exposures of granite occur on the R. L. Wyatt property, extending perhaps over a dozen or more acres of surface. The exposures occur both on a hill slope and in the adjacent valley bottom.

The rock varies from a medium to a fine-grained biotite-muscovite-granite, of light-gray color. The feldspars are of a more or less pinkish tone, which impart to the rock, at times, a mixed pinkish-gray color. In parts of the area the granite appears to be nearly completely massive but in others the schistose structure is strongly developed. Both pyrite and garnet are present in the granite, the latter in considerable quantity in places.

The granite is further penetrated by very many pegmatite veins ranging from a fraction of an inch to two inches in width, and conforming to no definite direction but cut the rock indiscriminately. Several sets of joints intersect the granite striking N. 20° E., N. 80° E., and approximately E.-W. No opening has been made in the exposures of the granite and fresh specimens could not be obtained with the hammer.

ROLESVILLE.

Five miles east of Wyatt's and one-quarter of a mile S. 40° W. from Rolesville on the J. M. Fleming farm is a flat-surface granite mass less than a half dozen acres in extent exposed on a gentle southeast slope (five degrees). A single small opening has been made along the margin of the exposure and a few stones were obtained for local use.

The rock is a biotite granite varying in texture from medium to fine-grained, light gray in color with a very faint pinkish tint imparted by similarly colored feldspar. Most of the area, however, is composed of a uniform medium-textured and pinkish gray granite.

Microscopical Examination.—Thin sections of this granite under the microscope show its composition to be orthoclase, microcline, acid plagioclase, quartz, biotite, occasional shreds of muscovite, apatite, zircon and magnetite as primary constituents, with chlorite, kaolin and iron oxide as alteration products. Microcline is variable in amount nearly equalling in one of the sections the orthoclase. Carlsbad twinning is occasionally observed among the potash feldspar. Plagioclase, as finely striated stout laths, is freely distributed through the sections in nearly as large proportion as the potash feldspar. Irregular areas of quartz-feldspar intergrowths are rather abundant. Drop-like inclusions of quartz and plagioclase are noted in the potash feldspar in micropoikilitic structure. The feldspars show some alterations into kaolin and muscovite. Deep brown and strongly pleochroic biotite is distributed through the sections and elongated shreds much altered to chlorite and containing inclusions of apatite and zircon. Zircon and apatite as prismatic inclusions also occur in the feldspar and quartz.

Jointing is developed at fairly close intervals in several directions but not too close to admit of the quarrying of dimension stone. The joints strike N. 20° E., and approximately E.-W., the latter set varying a few degrees north of west in places. The jointed surfaces are slickensided and are covered in places with pyrite, which seems to be absent from the rock. Distinct shear zones coincide with the E.-W. jointing, which is the direction of the major set of joint-planes. No veins nor segregations were observed in any part of the granite.

REDFORD FARM.

About three-quarters of a mile S. 40° W. of Rolesville is a flat-surface outcrop on the J. F. Redford farm, of less than one acre in extent, of a light gray slightly pinkish tint, medium fine-grained, biotite-granite. The rock is cut in places by a few small veins of pegmatite, and it contains some disseminated grains of pyrite.

Microscopical Examination.—Under the microscope this granite has essentially the same composition as that described above on the Fleming place, except that plagioclase is only sparingly present and orthoclase and microcline make up the feldspathic constituent with the former in excess. Micrographic intergrowths of the quartz and feldspar are quite common. Carlsbad twinning is occasionally observed. Biotite is but sparingly

distributed through the section, altered in part to chlorite, and much of it is leached with the liberated yellow iron oxide quite freely staining the section.

The rock is more closely jointed than the granite outcropping on the Fleming place described above, and the shearing has been greater, accompanied by an increased development of pyrite on the slickensided surfaces of the joints. Two sets of joints are developed striking N. 20° E., and E.-W. The exposure was opened some years ago and some of the stone was obtained for sills in the building of Wake Forest College.

The same rock extends southeastward from this place for a distance of at least 5 miles and many large exposures of the same character are reported. A number of exposures of granite similar to that already described near Rolesville are reported 2 miles southeast of this place on the property of S. W. Terrell.

Diabase.—One mile northeast of Rolesville on the farm of Moses Williams, a diabase dike approximately 100 feet wide and striking N. 20° E. penetrates the granite similar to that found to the southwest of Rolesville.

FRANKLIN COUNTY.

Exposures of granite are numerous over the middle and eastern portions of Franklin County, especially in the vicinity of Louisburg, the county-seat. Louisburg is located in an extensive granite area, outcrops of which occur along the various roads leading in all directions from the town. Usually the rock is deeply decayed yielding a typical light gray to deep red granitic product by which the granite may be readily traced over the surface. Fairly fresh granite is exposed in immense boulder outcrops and somewhat irregular small surface-masses. Both the normal even-granular granite and porphyritic granite occur, the former making up much the greater part of the rock exposed in the County. Porphyritic granite was noted at only one or two places.

No quarries have yet been opened at any locality in the county, but several small openings have been made along Tar River at Louisburg, from which some stone was quarried to supply a local demand in the town.

THE LOUISBURG GRANITE AREA.

Louisburg has a nearly central position in the granite area of Franklin County. It is the county-seat and is located directly on Tar River, a large stream which cuts across the granite area. The town is further located about 10 miles east of Franklinton, a station on the main line of

the Seaboard Air Line Railway, between which towns a branch line of the Seaboard is operated. For convenience of description this granite area is here designated the Louisburg granite area.

On the east the area is bounded by an extensive north-south strip of crystalline schists and volcanics. It extends westward to within a short distance of Franklinton on the Seaboard Air Line Railway. To the north and south, the limits of the area have not been definitely traced, though its southward extension may probably include the granite outcrops along Moccasin Creek, in the extreme southeastern portion of the County and extending into the adjacent northeast corner of Wake County.

The rock is a medium coarse to fine-grained biotite granite of light gray color. In places the feldspars have a pronounced pinkish tint, imparting a similar color to the granite. The granite is even-granular in texture and over most of the area it is decayed to some depth.

The decay consists for the most part of a light gray soil, stained in places a rusty brown, in which nearly fresh particles of the essential minerals of the fresh rock may be easily identified. This zone passes at a moderate depth into partially though advanced decayed granite easily broken by very light blows of the hammer. The feldspars are dull and opaque more or less kaolinized. A slight leaching of the biotite is visible in which slight staining of the areas immediately surrounding the individual shreds of this mineral, from the liberated iron oxide. The partially decayed granite is exposed at many points along the road leading west from Louisburg, from blasting in grading the road. Perhaps the best exposure of the partially decayed rock is at the bridge over Tar River just across from Louisburg.

Exposures of the nearly fresh granite occur along the river road beginning about 4 miles northeast of Franklinton and continuing into Louisburg. Along the same road, at distances of 3 and $2\frac{1}{2}$ miles, respectively, northwest of Louisburg, the outcrops are especially noteworthy. The exposures are in the form of immense boulders and flat-surface masses, and are rather numerous over parts of the Ruffin place one to 2 miles west of Louisburg.

On the west side of Tar River about 200 paces from the Louisburg bridge considerable blasting has been done recently in grading the road, and the partially decayed granite was utilized for macadam on the road. An excellent section 12 to 15 feet in depth in the partially decayed rock is exposed on the south side of the road near the bridge in which the jointing is shown to advantage. The joint-planes are spaced at close intervals striking N.-S., N. 80° E., and N. 20° W., the last set being apparently less conspicuously developed than the other two.

Within the limits of Louisburg, a few hundred paces south of the bridge and immediately on the east side of the river, in the rear of the county jail, two small openings were made many years ago in low ledge outcrops of the granite. The jail was built of the stone quarried from the largest of these openings. The granite is penetrated in both openings by many pegmatite veins which do not conform to any given direction and which vary from an inch to 6 inches in width. These veins are composed of coarse crystallizations of quartz and feldspar, the latter predominating, through which are distributed scattered light-colored plates of mica. Two sets of joints intersect the granite striking N. 80° W., and N. 20° W.

Microscopical Examination.—A thin section of the rock from the Louisburg openings in the rear of the county jail showed a medium-textured biotite granite, composed of the principal minerals orthoclase, microcline, acid plagioclase, quartz, biotite, muscovite, apatite, zircon, iron oxide, chlorite and kaolin.

Orthoclase is the predominant feldspar with but little microcline, but much striated acid plagioclase is distributed through the section. More or less alteration of the feldspathic constituent to muscovite and kaolin is noted. The simultaneous crystallization of a portion of the feldspar and quartz is indicated in the irregular areas of micrographic intergrowths of quartz and feldspar. Prismatic inclusions of apatite and zircon characterize to some extent each of the three principal minerals, namely, feldspar, quartz and biotite. Biotite is of the usual kind, partially altered to chlorite and it is associated with occasional shreds of muscovite.

Along the Louisburg-Franklinton road, which follows closely the railroad in an east-west direction between the two towns, numerous outcrops of the same granite occur. At the railroad crossing by the wagon road, $3\frac{1}{2}$ miles west of Louisburg, blasting was necessary and many large masses and blocks of the medium gray, moderately fine-textured granite are scattered over the surface. Occasional rounded pinkish feldspar phenocrysts are distributed through the granite, but it is essentially an even-grained granite of desirable quality. It differs from the granite opened in Louisburg in being a shade darker in color and containing some pinkish feldspar. In general appearance the rock is not very unlike that quarried at Greystone in Vance County, except that it is entirely massive.

Microscopical Examination.—Under the microscope the thin section indicates a medium fine-textured biotite-granite, composed of orthoclase, a little striated plagioclase, quartz and biotite, the latter largely altered

to chlorite. Biotite shows further alteration in several cases into a colorless mica. Microcline and microperthite are absent from the section and in this respect differ from the thin sections examined from the adjoining counties in this part of the State. Orthoclase shows some twinning after the Carlsbad law. Both feldspars indicate considerable alteration, principally, into kaolin. Both micropoikilitic and micrographic structures are sparingly developed in the feldspars. The usual occurrence of zircon and apatite appears. Inclusions are rather common in the three essential minerals quartz, feldspar and biotite. Considerable alteration of both the biotite and the feldspars is marked, and the fracture lines crossing the light-colored minerals are in some cases stained yellow from the liberated iron oxide of the biotite. No injurious or harmful minerals were noted in the thin section of this granite.

This granite is apparently a desirable stone for general building purposes and quarries might be advantageously worked in almost any of the principal outcrops. It extends along Tar River southeastward to near Springhope in Nash County and is again reported along Moccasin Creek in Franklin and Wake counties.

Porphyritic Granite.

About 4 miles northeast of Franklinton on the Simms bridge road, small outcrops of a coarse-textured porphyritic biotite granite occur on the Wiley place. The rock is light gray in color and in an advanced stage of decay not permitting the collecting of fresh specimens. The phenocrysts are large feldspars more or less idiomorphic in outline and pink in color. Biotite inclusions of the groundmass are developed in the phenocrysts. No opening has been made and this constitutes the only area of true porphyritic granite noted in the County, although a porphyritic tendency is indicated in several granite exposures to the west of Louisburg.

Dikes of Basic Igneous Rocks.

Along the two roads mentioned above between Franklinton and Louisburg, the granite is intersected in a number of places by basic dikes of the diabase type; but only the more important ones are mentioned.

Two miles northeast of Franklinton on the Simms bridge road, a diabase dike of considerable width and trending northwest cuts the granite. Four miles west of Louisburg on the river road, a second dike approximately 25 feet wide and having a northwest strike is observed penetrating the granite. Three and a half miles east of Franklinton on

distributed through the section, altered in part to chlorite, and much of it is leached with the liberated yellow iron oxide quite freely staining the section.

The rock is more closely jointed than the granite outcropping on the Fleming place described above, and the shearing has been greater, accompanied by an increased development of pyrite on the slickensided surfaces of the joints. Two sets of joints are developed striking N. 20° E., and E.-W. The exposure was opened some years ago and some of the stone was obtained for sills in the building of Wake Forest College.

The same rock extends southeastward from this place for a distance of at least 5 miles and many large exposures of the same character are reported. A number of exposures of granite similar to that already described near Rolesville are reported 2 miles southeast of this place on the property of S. W. Terrell.

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to chlorite. Biotite shows further alteration in several cases into a colorless mica. Microcline and microperthite are absent from the section and in this respect differ from the thin sections examined from the adjoining counties in this part of the State. Orthoclase shows some twinning after the Carlsbad law. Both feldspars indicate considerable alteration, principally, into kaolin. Both micropoikilitic and micrographic structures are sparingly developed in the feldspars. The usual occurrence of zircon and apatite appears. Inclusions are rather common in the three essential minerals quartz, feldspar and biotite. Considerable alteration of both the biotite and the feldspars is marked, and the fracture lines crossing the light-colored minerals are in some cases stained yellow from the liberated iron oxide of the biotite. No injurious or harmful minerals were noted in the thin section of this granite.

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the Louisburg-Franklinton road a coarse-grained diabase dike about 350 feet wide is exposed for some distance on both sides of the road, on the Green place. Its trend is northwest and it cuts the granite. (Results of tests of this rock for road material are given on p. 265). Again at the railroad crossing in front of the Parnell house, a fine-grained diabase dike is crossed by the wagon road and is exposed in a shallow cut along the railroad, conforming to a general northwest strike.

Microscopical Examination.—Under the microscope a thin section of the rock from the large dike $3\frac{1}{2}$ miles east of Franklinton shows a typical olivine diabase. It is composed of slender but long stout laths of striated plagioclase, whose extinction angles measured against the twinning lamellæ correspond to labradorite varying in composition from $Ab_1 An_1$ to $Ab_1 An_3$; large partially idiomorphic plates of greenish augite filling the interstices, olivine and a little magnetite. The augites always show good cleavage development in one direction and at times both cleavages are well developed. By polarized light it is of light greenish color, some of which is moderately strongly pleochroic, from red to green. The olivine usually occurs in more or less aggregated areas in association with the augite, considerably altered along the cracks to serpentine. In some instances only small particles of the fresh olivine appear in the black mass of serpentine.

WARREN COUNTY.

The most important exposures of granitic rocks in Warren County are found at Warrenton, the county-seat, and to the north and northwest of Warren Plains, a station on the Seaboard Air Line Railway. A few stones have been quarried in each locality, but no regular quarries have been worked in the County.

WARRENTON AREA.

Small exposures of a dark gray biotite-hornblende-gneiss occur at several places near together, just beyond the west limits of the town. The rock is irregular in structure and composition, and is only suited for rough grades of work. A rock crusher is located at the opening and the stone quarried is crushed and used for macadamizing the streets of Warrenton. Two sets of joints intersect the gneiss striking N. 30° W., and N. 60° E.

A second opening is made in an outcrop about a quarter to a half mile south of the one described above. This one was worked in 1867-'68 for stone to build the county jail. Jointing is well developed and some scattered crystals of pyrite are observed in the rock.

Microscopical Examination.—Microscopic study of a thin section of the rock reveals a fine-textured biotite-hornblende gneiss, in which the parallel arrangement of the minerals in a given direction is pronounced. Besides biotite and hornblende, the principal minerals in the rock are orthoclase, with an equal or greater amount of striated plagioclase, quartz, epidote, and chlorite. Microcline entirely fails. The hornblende nearly equals biotite in amount, and when unaltered it is deep brown and pleochroic, with the prismatic cleavages well developed. Much of it is altered to the deep green or bluish green “reedy” hornblende. Biotite is of the usual kind. Some epidote, resulting from the interaction of the ferro-magnesian minerals and the feldspars, is present. Considerable chlorite is distributed through the section as a derived product from the alteration of biotite. Quartz is equal to or greater in amount than the feldspathic constituent. A slight sprinkling occurs of the usual microscopic accessories.

THE WARREN PLAINS AREA.

About 2 miles north of Warren Plains, a station on the Seaboard Air Line Railway, are several exposures of granite near together, on the Norwood place. The largest outcrop extends over less than one-half acre of surface from which a few stones were quarried some years ago for foundations in the neighborhood.

The rock is a fine, even textured, nearly white muscovite-granite. The mica is of a decided yellowish color with a slight green tinge, and contrasts rather strongly in color with the light-colored quartz and feldspar. It is only sparingly distributed through the rock as small irregular plates.

Microscopical Examination.—A thin section of the rock examined under the microscope revealed a fine-grained muscovite granite composed of orthoclase, quartz, much broad and finely striated acid plagioclase, a few pieces of microcline, occasional microperthite intergrowths, muscovite, some garnet, and iron oxide. Feldspar is the predominant constituent, with much quartz and very little muscovite. Occasional inclusions of the usual microscopic accessories were observed.

The granite is massive, quite uniform in color and texture, and contains so far as could be observed no injurious minerals. Jointing is well developed in three directions, spaced at rather close intervals, and striking N. 60° W., N. 45° E., and N. 10° E. Jointing is not, however, too closely spaced to prevent the quarrying of large blocks. Outcrops of the same granite occur nearby on the Norwood and the adjoining

farms. While the exposures are largely in the nature of flat-surface masses, boulder outcrops are not entirely lacking.

About one-quarter of a mile east of the Richmond division of the Seaboard Air Line Railway, one mile northwest of Wise siding and about $1\frac{1}{2}$ miles northwest of the granite exposure on the Norwood place described above, is a small opening in a biotite muscovite-bearing granite of somewhat coarser texture. The outcrop is on the Paschal place, and some of the stone was quarried from it during the winter of 1903 for general building and street purposes.

The rock is a medium light gray massive granite and of medium texture. It is coarser in texture and darker in color than the granite described above on the Norwood place. Biotite is regularly distributed through the rock and in places much red garnet is present, indeed so abundant in some of the hand specimens of the granite that a mixed pink and gray color is imparted. It should prove to be a desirable granite for general building purposes.

Microscopical Examination.—Microscopic study shows the rock to be a fine-textured biotite granite containing occasional shreds of muscovite. The other minerals are orthoclase, microcline, some striated acid plagioclase, a few pieces of micropertthite intergrowths, quartz, titanite, zircon, apatite, and rutile, and much chlorite derived from the biotite. Zonary structure characterizes the feldspar in some instances and is beautifully brought out in the alteration along parallel lines in the individual feldspar grains. Some of the feldspar is further characterized by Carlsbad twinning and micropoikilitic structure. Only a single rounded area of quartz-feldspar intergrowth was noted. Hair-like inclusions of rutile are abundant in most of the quartz. Biotite of the usual brown color and strong pleochroism is largely altered to chlorite. Much colorless mica is distributed through the section as an alteration product derived from the biotite and the feldspars. Inclusions are frequent in the feldspars, quartz and biotite.

VANCE COUNTY.

The granite of Vance County is perhaps amongst the best known in the State, and some of the quarries compare favorably with the most extensive ones in North Carolina. The area is a large one confined principally to the central and eastern parts of the County. Quarries are worked at several places in the County along the Seaboard Air Line Railway, chiefly at and near Greystone and Middleburgh stations. The quarries at Greystone have been worked almost continuously since they

were first opened about 20 years ago. Those near Middleburgh have only recently been opened. Within the past year a little of the granite has been quarried at Henderson, the county-seat, for street purposes.

The granite from the various quarries in Vance County has been used mostly for street purposes in the form of blocks; for coping and bridges; and to a less extent as a building stone. It has been shipped to numerous places in Virginia and North Carolina, especially to the eastern towns in these two States. The quarry waste is used for macadam and ballast.

THE GREYSTONE GRANITE AREA.

The Greystone quarries are located at Greystone, a station on the Seaboard Air Line Railway, 4 miles north of Henderson, the county-seat. They are the largest and best known quarries in eastern Carolina, and are located, with one exception, on the east side of the railroad. As shown below under the individual descriptions, the rock is a schistose granite, which works well and is admirably suited for street purposes for which there has been a large demand over the eastern Carolina-Virginia territory.

Microscopical Examination.—Microscopic examination of thin sections prepared from hand specimens of the rock collected from the various quarries around Greystone shows remarkable similarity. The rock is a biotite granite in which the schistose structure is more or less apparent in each of the thin sections, best emphasized in the biotite which is arranged along roughly parallel lines coincident with the longer axis of the individual filaments and shreds. The arrangement along parallel lines is much less apparent in the light-colored constituents. The principal minerals are quartz, orthoclase, microcline, occasional plagioclase near oligoclase, brown biotite, a little muscovite, and considerable inclusions of zircon and apatite. Much chlorite and kaolin are developed from the alteration of the biotite and feldspars, respectively. Also, with the exception of several intergrown shreds of muscovite with the biotite, the muscovite is entirely derived from the alteration of the feldspars.

Feldspar is the predominant constituent, consisting largely of orthoclase and microcline with many intergrown stringers of an acid plagioclase. A subordinate amount of striated plagioclase individuals, whose extinction angles indicate oligoclase, is shown in most of the slides. In many cases the potash feldspars display micropoikilitic structure and occasional twinning after the Carlsbad law. The feldspathic constituent is more or less clouded with irregular patches and areas of kaolin and minute scales of muscovite. The quartz and feldspar are frequently

intergrown in micrographic structure, clearly indicating that the period of formation of the quartz began before that of the feldspar closed.

The biotite is deep brown and strongly pleochroic. It bleaches to green on alteration and is largely altered to yellow-brown and brown, nearly black, opaque chlorite. Its usual occurrence is in elongated shreds and in amount it is much less than quartz or feldspar. Inclusions are somewhat frequent in the three principal minerals quartz, feldspar, and biotite. The microscopic accessories present no noteworthy features.

THE OLD GREYSTONE QUARRY.

This quarry, owned by P. Linehan and Sons, is the largest one in the County, and is located on the west side of the Seaboard Air Line Railway near the depot at Greystone, with which it is connected by a spur track. It was opened more than 20 years ago and was regularly worked for the first 15 years, but operations have been suspended for the past 5 years. During the period of operation it was well equipped with steam derricks, drills and hoisting engines for quarrying and handling the stone. The opening covers about 2 acres of surface in extent worked to an average depth of 35 feet.

The granite decay at the surface, including soil, will average about three feet in thickness. A much greater thickness is attained in some places, as much as 15 feet in extreme cases, and it is thinner in others. Near the top of the opening the rock weathers into thin horizontal sheets or bands, which become much less well defined lower down. Near the bottom the sheets thicken to as much as 12 and more feet. Jointed structure is well defined in one direction, N. 60° E., and cuts the rock at irregular distances or intervals. In some places zones of close jointing spaced at intervals of several feet occur, but over most of the quarry the joints are spaced at wide intervals and stone of almost any dimensions can be quarried. The surface of the joint-planes are often smooth, more or less polished and striated from movements of the blocks. They are coated with a thin veneer of the usual dull yellowish-green mineral matter, probably damourite in part, a dynamic alteration product derived from the original minerals of the granite.

The granite is further penetrated by very many veins and dikes which vary in width from less than one inch to many inches. They include segregation veins, pegmatite and fine-grained granite dikes. In strike they conform, as a rule, to a north-south direction. Pink feldspar forms the most abundant mineral in the veins and dikes, and they all contain some biotite, present as large platy masses in the pegmatite and as very

small shreds in the fine grained dikes. Quartz is variable in amount, but never entirely fails. Small irregular, roughly rounded dark-colored bunches of segregation areas of biotite were occasionally noted in the granite. Apart from the pronounced finely schistose structure of the rock, pressure-metamorphism has produced a marked tendency toward segregation into alternating dark micaceous bands with lighter colored ones of quartz and feldspar. The strike of the schistosity is, in general, north and south.

The rock is a fine-grained biotite granite-gneiss with a pronounced porphyritic tendency. It is dark gray in color with a pinkish cast imparted by the prevailing pink colored feldspars. On close inspection the rock shows a rather decided mixed pink and gray color. The feldspathic constituent is in larger sized individuals than the other mineral components of the rock. Biotite occurs in very small black lustrous shreds orientated in a parallel direction to their longer axes.

The granite from this quarry has been shipped to numerous places in Virginia and North Carolina, where its principal use has been in the form of blocks and curbing for street purposes; for coping and bridges; and to a limited extent for a general building stone.

THE NEW GREYSTONE QUARRY.

This quarry is located approximately 150 yards west of the Old Greystone quarry described above and is owned by the same company. It was opened in the fall of 1902, and in June 1903, the opening covered less than one-half acre of surface in extent, and had been worked to an average depth of less than 12 feet.

The fresh rock is covered to a depth of 3 to 6 feet of soil and decayed granite, which makes stripping necessary to this depth, in quarrying. Two sets of joints striking N. 60° E., and N. 5°-10° E., intersect the rock. The latter set of joints is less well defined than the former. Unlike the Old Greystone quarry nearby, only occasional intersecting pegmatite veins were exposed in the opening. These are in all respects similar to those described above penetrating the granite of the other quarry, composed of pink feldspar and quartz with a little copper- to lighter colored mica, biotite. No free sulphides or other injurious minerals likely to discolor the rock on exposure are present in any of the granite in this quarry.

The rock in this opening is the same as that quarried in the old opening nearby. The results of the microscopical examination of thin sections of the granite from the two quarries are given on page 45. The

pinkish feldspars give a similar tint to the gray rock, which on close inspection appears to be of a more or less mixed gray and pink color. The texture of the granite is the same for the two openings, but the rock of the new opening is perhaps slightly less schistose and more massive in places with correspondingly more uniformity in color than that of the old one.

The granite from this quarry is shipped to Norfolk and Portsmouth, Virginia, where it is used for street purposes in the form of blocks or curbing. A rock crusher is operated at the quarry for working up the waste for use in granulithic work.

THE GREYSTONE GRANITE AND CONSTRUCTION COMPANY'S QUARRY.

This quarry is located at the base of a slight slope about three-fourths of a mile northwest of the depot at Greystone. The hill-slope back of the quarry rises some 25 to 30 feet above the opening. The quarry was first opened in 1889 and was worked constantly for about 6 years, but has been idle for the past 5 or more years. At the time of working it was well equipped with the necessary modern machinery for quarrying and handling the stone, and a railroad spur was laid and operated between Greystone and the quarry. The opening is a large one averaging nearly 250 feet each way and worked to a depth of about 25 feet.

The opening shows along the face decay from the surface downward for 2 to 10 feet in depth, composed largely of a granite soil of red to light gray color and thin partially decayed nearly horizontal sheets of moderately firm rock. As in the Old Greystone quarry, the horizontal parting planes are less well defined lower down in the fresh rock, although they are variable, separating the rock into layers or sheets 8 or 10 feet thick. Two sets of joints of about equal development and intersecting at right angles cut the granite approximately N.-S., and E.-W. These greatly aid in the quarrying of the stone and are sufficiently spaced to admit of any desirable size blocks being quarried. Pegmatite veins 6 to 8 inches across in the larger ones penetrate the granite striking in a general north-south direction. Small irregular segregation areas of black mica are sometimes noted in the rock.

The rock is essentially the same as that of the Linehan quarries described above. It is somewhat lighter in color, but has a pinkish tone, varying from fine to medium-grained in texture, and distinctly schistose in structure. The schistosity conforms to a general north-south direction. The feldspars will average larger in size than the other mineral constituents and is white or of light color with the usual porphyritic tendency indicated. The biotite occurs in somewhat larger

plates than that of the Linehan quarries described above, and it is highly lustrous and black in color.

So far as it was possible to learn, the granite from this quarry was worked principally into blocks for use in various towns in the Southern States. The good qualities of the granite are well shown in a block of the stone with polished and dressed faces on exhibition in the State Museum in Raleigh.

THE SEABOARD AIR LINE RAILWAY QUARRY.

The railroad quarry is located in a broad but slight depression occupied by a small stream, about 2 miles northeast of Greystone station. In all, several acres of surface have been stripped to a moderate depth over the gentle slopes on both sides of the small stream. It was first opened about 3 years ago and was worked for 6 or 8 months by the Seaboard Air Line Railway. Operations were then suspended for about one year when work was again resumed under lease and continued for some 8 or more months. It has not been worked during the past year. A spur track is laid from the main line near Greystone to the quarry, a distance of about $1\frac{1}{2}$ miles. The quarry is in very bad shape and indications point to very poor judgment in working it.

Three rather strongly contrasted phases of the granite are developed in the rock of this quarry. The first, which comprises the main body of the rock, is the typical Greystone granite, dark gray in color with a faint pinkish tone and generally fine-grained in texture. In the hand specimens the schistose structure is much less marked than in the Greystone rock proper, and it exhibits a pronounced porphyritic tendency. The second phase is a medium-textured, uniformly light-pink granite containing a much smaller amount of biotite than the first. The rock is decidedly schistose in structure, highly feldspathic, and the biotite is distributed along roughly parallel disconnected bands of knife-edge thickness. As nearly as could be determined, the width of this zone as exposed in the opening is not less than 600 feet, with a north-south direction. The porphyritic tendency noted in the first phase of the granite is not shown in the second one. The third and last phase is a dark blue-gray biotite-granite generally finer grained than the other two and containing a larger amount of biotite. This phase of the rock is usually developed as a narrow zone varying from 2 to 6 feet across between the pink and the gray granite.

The three phases of the granite in this quarry are each alike schistose in structure, the schistosity striking north and south; and the jointing

is likewise continuous through them in the same general directions. While the quarry is not sufficiently developed to conclusively state the exact relations and significance of these three variations in the rock, such data as were available would seemingly indicate that they are phases of the same rock as stated above and are not separate intrusions. The differentiation was possibly begun with the cooling of the magma and completed by the intense dynamic metamorphism to which the granite has been subjected. Indeed banding on a small scale, differentiation into dark and light colored bands, due to metamorphism are distinctly noticeable in some parts of the quarry.

Three sets of joints intersect the granite striking N.-S., E.-W., and NW.-SE. Jointing in the E.-W. direction forms the major set of planes and the surfaces of this set are usually slickensided after the fashion of those described above in the Old Greystone quarry. Intersecting material of pegmatitic composition penetrates the granite rather frequently, varying from one inch to more than 6 inches across and in most cases conforming to a strike of N. 10° E.

The stone quarried from this opening is reported to have been used both for ballast and for street purposes.

One other exposure of the granite near Greystone station between the main track of the railroad and the New Greystone quarry was recently opened to a small extent, but was shortly abandoned on account of the numerous veins and the irregular texture of the rock.

THE MIDDLEBURGH GRANITE AREA.

Two quarries, near together, have recently been opened on the west side of the Seaboard Air Line Railway, one mile west of Middleburgh station and about 3 miles north of Greystone on the estate of James R. Carroll. The granite is essentially the same as that quarried at Greystone. On the whole it probably contains a very slightly increased amount of biotite and is correspondingly darker in color. The feldspars are chiefly light in color or white with only the barest pinkish cast observed. It is fine-grained in texture, displaying a marked porphyritic tendency in the feldspathic constituent. The biotite is distributed in fine black shreds along parallel lines arranged in the direction of their longer axis. Hand specimens from the two openings are indistinguishable.

Microscopical Examination.—Under the microscope the thin sections of the granite from the Middleburgh quarries are as closely identical in all respects with those from the Greystone quarries as is possible. The

rock is a biotite granite distinctly schistose and composed of the same minerals in practically the same proportions as the Greystone area. Feldspar predominates consisting of the potash varieties, orthoclase and microcline, with micro-perthitic intergrowths and occasional individuals of an acid plagioclase. Some alteration to kaolin and muscovite is indicated in the cloudy and opaque areas over the feldspar surfaces. Micropoikilitic structure in the potash feldspars is common and Carlsbad twinning is occasionally observed. Micrographic intergrowths of quartz and feldspar, indicating the overlapping of the periods of separation from the magma of these two minerals, are frequent. Biotite is largely altered to chlorite and it is identical in occurrence and microscopic properties with that in the Greystone granite described above. The microscopic accessories are the same in the granite from the 2 areas.

The first quarry was opened in 1899 and is located about 150 yards from the Carroll residence. The opening will average about 400 feet long by 199 feet wide, and has been worked to an average depth along the quarry-face of 25 feet. A 22-foot quarry-face is developed lengthwise of the opening, covered at the top by an average depth of about 4 feet of a granite soil derived from the decay of the rock. A small force was working during the summer of 1903 and the quarry has been worked a part of each year since it was first opened.

Only one set of joints cuts the granite striking E.-W., and these are spaced at some distance apart, less than a half dozen planes being visible in the entire quarry. Very few seams were noted in the rock. A tendency toward banding is indicated in places, separation into alternating darker and lighter colored layers, in a direction N. 20° E., which is the prevailing strike of the schistosity.

The rock is a granite-gneiss of dark-gray color, containing perhaps a slightly larger proportion of biotite than that quarried at Greystone. It is fine-grained and is remarkably uniform in both color and texture. The feldspars are mostly white and show much less of the pink color so characteristic of the former area. The rock works readily and seems admirably suited for the use made of it.

The stone quarried up to date has been shipped mostly to Norfolk and Portsmouth, Virginia, in the form of blocks and curbing for street purposes. It has also been used to a limited extent in buildings. The method of quarrying is by steam drilling and blasting.

A second opening was made in an outcrop of the same granite in 1903, exposed along a small stream 125 yards east of the Carroll residence and 100 yards south of the opening described above. Quarrying had begun only in May, 1903, and the opening was a small one. The

sap, partially decayed granite, is only a few inches thick, which is shown in the partial discoloration from weathering. The rock is perhaps a shade coarser in texture in places than that of the nearby opening and the feldspars are prevailingly light in color with only the faintest pinkish tone discernible. Jointing and schistosity are the same as noted in the other opening already described. In all other respects the rock is identical in the 2 openings.

A small force was at work quarrying the granite in June, 1903, and the stone in the form of blocks and curbing was being shipped to Norfolk and Portsmouth, Virginia, for use on the streets. The stone from these 2 openings is hauled by teams to Middleburgh, one mile distant, where it is loaded on the cars for shipping.

THE HENDERSON GRANITE AREA.

The Greystone granite-gneiss extends southward 4 miles to Henderson, the county-seat of Vance County, where it is exposed in and beyond the northwest limits of the town, along the road. It has been opened to a slight extent on the western edge of the town affording opportunity for studying the fairly fresh rock. Some variation is observed in the rock at this point from that quarried further north at Greystone and Middleburgh. It has been more affected by pressure-metamorphism, and is accordingly an irregularly banded pink and gray granite-gneiss of fine to medium texture. In places it is more feldspathic and shows decreased biotite over the Greystone rock. The contorted bands of biotite contain occasional irregularly rounded feldspar phenocrysts.

Microscopical Examination.—The thin sections under the microscope indicate the presence of the same minerals and structure as noted in those of the granite from the Greystone and Middleburgh quarries, except that no plagioclase as single individuals is observed and the micro-poikilitic structure of the potash feldspars is less well defined. The thin section indicates, as in the field examination of the rock, effects of greater pressure-metamorphism than in the Greystone and Middleburgh quarries.

Two sets of joints cut the rock in this exposure, the major set striking N. 25° E., and a less well developed set striking N. 70° W. The general strike of the schistosity is N. 25° E. The surfaces of the joint-planes are coated in places with much epidote. The rock in this exposure is only suitable for very rough grades of work, such as macadam and ballast.

Outcrops of a similar granite to that quarried at Greystone are re-

ported in the vicinity of Williamsboro, in the same County, some 10 or more miles northeast of Henderson. The exposures occur some distance from the railroad and have not yet been opened, so that no definite statement can be made concerning them.

GRANVILLE COUNTY.

Granite boulders of light-gray color and medium texture are reported occurring in the vicinity and to the east of Oxford, the county-seat of Granville County. No quarries have been opened, but some of the larger boulders have been split and worked into curbing and foundation stone and for other purposes for local use. Owing to the large territory to be covered and the very limited time devoted to the field work, no detailed studies of the outcrops could be made.

RÉSUMÉ OF THE GRANITES OF THE NORTHEASTERN CAROLINA GRANITE BELT.

To recapitulate, it will be observed from the above detailed description of the granitic rocks in the 5 counties composing this belt, that extensive workable areas of different grades of granite are found, suited for all grades of work in which granite is used, except for the better grades of monumental stock. Systematic quarrying has been limited principally to areas in two counties of the belt, namely, in and around Raleigh in Wake County, and at and near Greystone and Middleburgh in Vance County. Quite a large supply of the stone has been quarried from both areas and the quarrying operations extend back over a long period of years, supplying a local demand for the stone in eastern Virginia and Carolina. The quarries opened are most favorably located with reference to the principal lines of railroad traversing the belt, affording ample and convenient transportation facilities. The granite outcrops are rather numerous over most of the belt and they are, in many instances, of sufficient size to admit of large quarries being opened without occasioning much surface stripping. Jointing in the granite is rarely close enough to render the quarrying of dimensional stone impossible. In several places, however, the rock is so freely penetrated by dikes and veins of pegmatite as to make it impossible to obtain dimension stone free from them. Deleterious minerals, such as free sulphides and iron oxides, which are a source of discoloration to stone on exposure, are practically absent from the granites of this belt.

The granites show but little variation in mineral composition over the entire area. With only one exception they are biotite-granites, contain-

ing occasional muscovite, and in 2 places hornblende is present. The exception noted is a muscovite granite occurring on the Norwood place 2 miles northwest of Warren Plains in Warren County. In texture the rocks vary from medium- to fine-grained, with porphyritic tendency noted in places. True porphyritic granite, however, is found at only one locality in the belt, namely, in Franklin County. Structurally, they vary from massive to schistose rocks, and are some shade of gray with a pronounced pinkish tone over much of the area imparted by similarly colored feldspars.

Microscopically, the essential minerals in the order of their abundance are feldspar, quartz, and biotite. Plagioclase is present in all the thin sections examined and it is usually present in considerable quantity. Microcline may occasionally entirely fail but it is usually present in large amount nearly equalling in many instances the orthoclase. Poikilitic, perthitic, and graphic micro-structures are developed to some degree in nearly all the thin sections studied. Both the feldspars and the biotite show some alteration in the sections to the usual secondary products derived from these minerals. The component minerals of the granites are closely and complexly interlocked, imparting thereby great strength and durability to the stone.

The quarried stone has been used principally for street purposes in the form of blocks and curbing, and for general building purposes, and in a number of other less important ways. Still another important use made of the stone is for macadam on the streets and the roads.

THE CAROLINA METAMORPHIC SLATE AND VOLCANIC BELT.

GENERAL DESCRIPTION OF THE BELT.

The area of metamorphic slates and schists and altered volcanic rocks includes a belt extending in a general southwest direction across the middle portion of the State which forms a part of the eastern Piedmont plateau region. It varies in width from 8 to 50 miles and is included between the Carolina igneous belt on the west and principally by the Triassic belt of sandstone on the east (see map, Pl. III).

According to Nitze¹¹ the country rocks of this belt comprise (1) argillaceous, sericitic and chloritic metamorphosed slates and crystalline schists; (2) sedimentary pre-Juratrias slates; and (3) ancient volcanic rhyolites, quartz porphyries, and pyro-clastic breccias, often sheared. To

¹¹ Nitze, H. B. C., Bulletin No. 3, N. C. Geol. Survey, 1896, p. 28.

these may be added altered andesites¹² and rocks belonging to more basic igneous types not yet differentiated. The general strike of the schistosity of the rocks composing the belt is northeast and southwest, with a steep northeast dip.

Rocks of granitic composition have as yet been noted in only one county, comprised within the limits of the belt, namely, in Orange County; and these, so far as it is possible to judge from the exposures, seem to be of doubtful commercial value except for certain grades of rough work (see map, Pl. VI).

The very extensive areas of volcanic rocks found within the limits of this belt would doubtless prove upon investigation to be in many cases of some commercial value.

ORANGE COUNTY.

True granites are found at several localities in Orange County as follows: Three miles southwest of Hillsboro, the county-seat, on the Hillsboro-Oaks road; one mile northeast of Chapel Hill on Bolans Creek where crossed by the Durham Road at the east margin of the crystalline rocks near the contact with the Triassic sandstones; 5 miles a few degrees west of south from Chapel Hill on the Pittsboro road; 1½ miles north of Chapel Hill along the road and on the north side of Brockers Creek; and 4 miles north of Chapel Hill and 150 yards east of the railroad on the Brocker place.

To the north of Chapel Hill outcrops of a hard and tough, massive compact, dark gray and medium to fine-textured igneous rock resembling diorite occur for some distance. The most important outcrops of the rock noted were at the long trestle on the east side of the railroad, three-quarters of a mile from the depot at Chapel Hill in large boulder exposures; on the Hillsboro road a half mile north of Chapel Hill; and Blackwood Mountain 5 miles north of Chapel Hill. These exposures show a variation in the rock from a medium and uniform dark gray color to that of a somewhat lighter shade of a "salt and pepper" appearance. Further variation in texture is from fine to medium grain.

Blackwood is a conical peak which rises to a conspicuous elevation above the surrounding lowland. The rock shows the same variation in texture and color noted above. The feldspar in the coarser textured rock is a dull pink color. As yet no attempt has been made to quarry the rock in any of the exposures noted above but judging from the character of the rock it would probably prove desirable for certain uses. The cost of quarrying this rock would probably exceed that of normal granites.

¹² Watson, Thomas L., *Bulletin Geol. Soc. America*, 1902, Vol. XIII, pp. 353-376.

THE HILLSBORO AREA.

On the Hillsboro-Oaks road, 3 miles southwest of Hillsboro, is an exposure of very hard, dull pink granite on the Gray farm. A small opening was made in the outcrop many years ago and a very limited quantity of the stone was quarried. The extent of the granite is unknown since only the single outcrop is found, which is of small size.

It is a fine-textured granite composed apparently of quartz and feldspar and very subordinate amount of a dark bisilicate showing in the hand specimen considerable alteration. Variation in color is from a pronounced pink to a very dull, dirty pinkish tone. It is much sheared, mashed and jointed in the exposure which renders the stone wholly unsuited for general building and other purposes requiring dimension stone. Two sets of joints intersect the rock striking N. 20° E., and N. 60° W. Several small veins or dikes not exceeding two inches in width penetrate the granite parallel with the set of joints striking N. 20° E. The rock is apparently without grain or rift and is entirely useless as a building stone.

Microscopical Examination.—Under the microscope a thin section of the rock showed a complexly interlocking aggregate of feldspar and quartz with a very subordinate amount of biotite, which is greatly altered. The feldspathic constituent comprises orthoclase, microcline and plagioclase, very extensively altered and thickly crowded with dust-like particles of red iron oxide. Occasional scattered grains of magnetite occur.

THE CHAPEL HILL AREA.

Boulder and ledge outcrops of granite are exposed along Bolans Creek where crossed by the Durham road, one mile northeast of Chapel Hill, near the contact of the crystalline rocks with the Triassic sandstones. The rock indicates much variation in texture from a very fine-grained irregularly porphyritic granite to a moderately coarse-grained even-granular granite of a decided pink color. Reddish pink feldspar, quartz and a small quantity of biotite are apparent to the unaided eye. The rock is entirely massive and is intersected by several sets of joints. No attempt has been made to quarry the stone and its marked variable texture would make it undesirable as a general building stone.

On the Pittsboro road, 5 miles south of Chapel Hill, is an area several miles in width of a very fine and even-textured granite of faint pinkish color. Exposures in the form of boulders are numerous over the area along the road. The rock yields a light gray nearly white sandy soil.

In the hand specimens dull pink feldspar greatly predominates with a

little quartz and some biotite. No openings have been made in any of the exposures upon which to base an accurate judgment of its working qualities, but from the general appearance of the stone in the outcrops it is likely that the rock will prove to be of some commercial value.

The outcrop on the Claytor place on the north side of Brockers Creek, one and a half miles north of Chapel Hill, shows more or less variation in texture and color, though the rock is usually dark gray and of a very fine texture. No statement can be made of the working qualities of the stone.

Four miles north of Chapel Hill and 150 yards east of the railroad is an exposure on the Brocker place, of pinkish gray granite with porphyritic tendency, containing large laths of pink feldspar. It lacks uniformity in both color and texture and for this reason it would not prove a very desirable stone for general building purposes.

THE CAROLINA IGNEOUS BELT (THE MAIN GRANITE BELT).

GENERAL DESCRIPTION OF THE BELT.

This belt, shown on the accompanying map, Plate VI, occupies a nearly central position in the Carolina portion of the Piedmont plateau. It crosses the State in a general northeast-southwest course, beginning at a point to the east of Danville, Virginia, and extending southwestward into South Carolina. In width it will probably average from 15 to 50 miles, and it is traversed for most of its length by the main line of the Southern Railway. The belt is further crossed by many of the principal railroads in the State at rather close intervals, which join the main line of the Southern at the principal towns of Greensboro, Salisbury and Charlotte. It is thus made one of the most accessible areas in the State.

The limits of the belt are essentially those given by the State Geological Survey. Its southeast extension can, as a rule, be traced with comparative readiness along an irregular line marking the contact with the belt of metamorphic slates and volcanics. On the northwest it is bounded by an extensive area of gneisses and schists of the western Piedmont region, and the line of differentiation between the two formations is less easily determined. From observations made during the present investigation, it has been determined that the limits should be extended somewhat farther westward in places.

GENERAL GEOLOGIC RELATIONS.

The area is composed principally of plutonic igneous rocks belonging to 2 leading types, namely, granite and diorite. These may be massive or they may be more or less mashed and squeezed and schistose in structure. They are penetrated by dikes of granite and diabase and other basic igneous intrusive types. Areas of variable schists are by no means absent but are often observed over the belt in many places forming the country rock.

Dikes of granitic composition penetrate the rocks quite abundantly in places and are probably referable to apophyses given off from the larger granite masses. Sections exposed in the cuts along the Southern Railway and along the wagon roads in or near the towns of Concord, Salisbury, Lexington and High Point best illustrate these granite dikes or apophyses.

The granites are completely schistose in many places, one of the most noteworthy occurrences of which is the extensive granite-gneiss area on the Josey and adjoining places about 9 miles southwest of Salisbury in Rowan County. Perhaps the bulk of the granites within the Igneous Belt exhibit to some degree megascopic effects of pressure metamorphism in a more or less visible schistose structure.

The area is further traversed by very many intersecting quartz veins of both large and small size. The abundance of the quartz veins, usually concealed by the deep covering of rock decay, is indicated by the almost innumerable angular fragments of the quartz strewn over the surface of the area.

Two phases of the granite are prominently developed over many parts of the area, the porphyritic and the even-granular, which in nearly every case observed grades one into the other. A very pronounced zone of the porphyritic granite is traced in a northeasterly direction through a number of counties along the western margin of the belt. It is first observed to the southwest in Gaston County, in the vicinity of Gastonia, the county-seat, and passing northeastward through Iredell County, where large areas are exposed around Mooresville and Mount Mourne; thence to the west of Salisbury in Rowan County along the Yadkin River in Davie County, and to the southeast of Winston-Salem in Forsyth County. To the west of Salisbury in Rowan County the porphyritic granite has a width of from 4 to 8 miles. In places the feldspar phenocrysts almost entirely fail, again reappearing within a short distance in proportions equalling and at times exceeding the groundmass, in the ratio of the former to the latter.

Wherever observed throughout this area the rock preserves nearly

constant characteristics. It is a coarse-grained, medium to dark gray biotite-porphyritic-granite. The feldspar phenocrysts are persistently marked by idiomorphic outlines of very large size, measuring in extreme cases more than 2 inches in length by one inch across. They are usually white, though pink colored ones are not uncommon, and they nearly always contain more or less included biotite of the groundmass as large in size as that of the groundmass constituent. Twinning after the Carlsbad law is very frequent and the cleavage is pronounced. No orientation of the phenocrysts in the groundmass was strongly apparent.

The rock is readily traced by its decay. The feldspar phenocrysts are abundantly scattered over the surface in a partially kaolinized condition and the individuals are often split into smaller fragments along the cleavage lines, with whole ones quite numerous.

A second very prominent area of porphyritic granite is developed in Cabarrus County to the north and northwest of Concord, the county-seat, which is quite similar to that described above. To the southwest of Concord about $3\frac{1}{2}$ miles is an area of coarse-grained augite-syenite, closely related to monazite, which possibly grades into even-granular and porphyritic granite on the northeast and southwest sides. A description of these rocks is given in detail under the respective counties in which they occur.

Descriptions of the even-granular granites are best brought out under the individual areas. Hardly without exception, they are biotite granites of some shade of gray and they may vary from fine to coarse grain in texture.

The diorites show considerable variation in composition, color and texture, features best described and brought out under the individual areas. So far as differentiation in the field was possible between the diorites and the granites, the contacts in the best exposures are always sharp and the two types of rock were not observed grading into each other. The sharp and distinct line between the two types is well drawn in the rocks exposed in the railroad cuts to the north and south of Woodleaf, a station on the Charlotte-Winston division of the Southern Railway, in the southwest corner of Rowan County.

AGE RELATIONS OF THE ROCKS.

From Nitze's¹³ examination of the contact between the rocks of the igneous belt and those of the Carolina slate belt on the east, he inferred from the nature of the contact that the rocks of the Igneous Belt were

¹³ Nitze, H. B. C., and Hanna, Geo. B., Gold Deposits of North Carolina, N. C. Geol. Survey, Bull. No. 3, 1896, p. 107.

the younger. The few contacts between the rocks of these two belts examined by the writer tend to confirm Nitze's work.

The so-called slate belt, including volcanics, constitutes Emmons' "Taconic and was later mapped as Huronian by Kerr."

Nitze¹⁶ assigned the rocks of this belt to pre-Cambrian age, provisionally to the Algonkian as defined by Van Hise.¹⁷ A study of some of the altered volcanics of both acid and basic types of Chatham and Orange counties in this belt, by the late Doctor George H. Williams,¹⁸ lead him to refer them to a pre-Cambrian age. Recent work by Watson¹⁹ on a group of altered volcanics, meta-andesites, in the northern part of the belt showed the rocks to be pre-Cambrian in age.

The igneous belt is limited on the west by an extensive belt of schists and gneisses which has been mapped by the State Geological Survey as probably Archaean.²⁰ The granites and diorites of the Igneous Belt exposed along the eastern border of the schist and gneiss belt are clearly younger in age than the latter rocks. Fairly good contacts between the rocks of the two belts were carefully noted in a number of places, and wherever these were observed the granites and diorites were found cutting across the schistosity of the schists and gneisses and otherwise showed their intrusive character into the gneiss-schist complex.

As elsewhere shown in this report, the granites of the igneous belt are in part massive and in part schistose rocks and in places they exhibit further effects of pressure-metamorphism in crushing and fracturing. The pronounced schistose granites do not in all cases grade into those of massive structure. On this basis then the granites are inferred to belong not to the same period of intrusion but rather to at least two separate and distinct periods. Enough detailed work has not yet been done in this belt to completely differentiate and define the exact age relations of the rocks. Until this detailed work is accomplished, accompanied by accurate mapping, a definite statement cannot be made.

Should the premises stated above prove correct and the ages assigned to the belt immediately on the east and west of the igneous belt be established, it would follow that the rock complex composing the Igneous Belt might in part be pre-Cambrian and in part of later age, Cambrian or even post-Cambrian.

¹⁴ Emmons, E., Geological Report, Midland Counties of North Carolina, 1856.

¹⁵ Kerr, W. C., Map accompanying Geology of North Carolina, 1875, Vol. I.

¹⁶ Nitze, H. B. C., and Hanna, Geo. B., Op. Cit., p. 44.

¹⁷ Van Hise, C. R., Correlation Papers, Bull. No. 86, U. S. Geol. Survey, p. 495.

¹⁸ Journ. Geology, 1894, Vol. II, pp. 1-32.

¹⁹ Watson, Thomas L., Bulletin Geol. Soc. America, 1902, Vol. XIII, pp. 353-376.

²⁰ See maps accompanying the various reports of the N. C. Geol. Survey.

Likewise the dikes of basic igneous rocks penetrating the rock-complex of the igneous belt are not all of the same age but are to be referred to at least two separate periods of intrusion. Many of these dikes are correlated with similar ones intersecting Triassic sandstones to the east and hence are of the Juratrias age. Others which are noted penetrating the schistose rocks are likewise schistose to a more or less degree or otherwise altered, indicating their intrusion at a period prior to that of the metamorphism inducing schistosity in the enclosing rocks. That is, the disturbance affecting the enclosing rock similarly affected the intersecting dikes of basic igneous material. This series of dikes is therefore younger than the enclosing rocks but older than the period of disturbance inducing the schistosity.

DESCRIPTION OF THE INDIVIDUAL GRANITE AREAS.

Some of the largest and the most important granite areas in the State are included within the limits of the Carolina igneous belt. As a rule, the rocks composing the belt are deeply decayed but outcrops of the fresh or nearly fresh granite are somewhat frequent and they occur in every county comprised within the limits of the belt. The decay is, as a rule, characteristic of the underlying rocks from which it has been derived and the granites can usually be traced with considerable accuracy from the derived soil.

Named in order from south to north the belt includes either the whole or a part of the following counties: Gaston, Mecklenburg, Cabarrus, Rowan, Iredell, Davidson, Davie, Forsyth, Guilford, Alamance, and Caswell. With the exception of Caswell County, granite has been quarried to some extent in each of the counties named. Description of the individual areas is taken up by counties in the order here named.

GASTON COUNTY.

Numerous outcrops of granite occur over the central portion of Gaston County and a number of openings have been worked from time to time in the vicinity of Gastonia, the county-seat, to supply a local demand. The rock is usually deeply decayed yielding a pronounced characteristic light gray granitic soil by which it is readily traced over the surface. The nature of the decay indicates more the result of physical than of chemical forces, manifested in a goodly proportion of all the essential constituents in the fresh rock present in the decay. The biotite is nearly fresh and indicates but slight leaching from chemical action, which is further shown in the very slight discoloration of the decayed product

from the liberation of scant iron oxide. The feldspars have suffered more than the biotite and are very generally in an advanced stage of kaolinization.

Both a porphyritic and an even-granular facies of the granite is indicated in the outcrops and in the openings of the fresh rock. These exposures extend from within the limits of the town of Gastonia in a north, northwest, and east direction for several miles. The rock is a biotite granite of light to dark gray in color and varies from fine to medium coarse-grained in texture. With but few exceptions, a pronounced porphyritic tendency is indicated over most of the area.

Beginning at Gastonia and extending for a distance of about $2\frac{1}{2}$ miles east-northeast along the Gastonia-Charlotte macadam road is a belt of gray coarse-grained porphyritic granite. The feldspars make up at least 50 per cent of the rock mass and, in places, more. The phenocrysts are white opaque and very large, measuring in extreme cases more than an inch in length. They are usually flat-tabular, idiomorphic in outline and contain biotite inclusions of the groundmass. A tendency toward orientation in the phenocrysts is exhibited in places. The rock is exposed in shallow cuts along the road and in an advanced stage of decay similar in character to that described above on page 58. The phenocrysts observe essentially the same position and characteristics in the decay as in the fresh rock, except that they are dull in lustre and largely altered to kaolin.

About $2\frac{1}{2}$ miles east-northeast of Gastonia the porphyritic granite is in contact with a body of micaceous schists which are much crushed and closely jointed in places. The rocks are deeply decayed at the contact and no fresh exposures of them are to be found nearby but so far as could be made out, the granite is probably the younger rock intrusive into the schist.

THE GASTONIA GRANITE AREA.

North of Gastonia about $\frac{1}{2}$ mile beyond the incorporate limits, 2 small openings were made several years ago to obtain stone for local use as sills in the cotton mills in the town and as bases for monuments. The openings are near together in flat ledge exposures along a small stream fed from a nearby spring. The rock is a biotite granite of medium texture and gray color. It is fairly uniform in both color and texture and is of good quality. In places it is decayed to a depth of from 6 to 8 feet; the feldspars are partially kaolinized while the biotite manifests scarcely any alteration.

Two sets of joints striking N. 60°-70° W., and N. 40°-60° E., cut the granite at sufficiently spaced intervals to admit of large size blocks being quarried. Several quartz-feldspar veins free from mica and not exceeding 1 to 2 inches in width were noted in the openings. In addition to these occasional irregularly rounded segregation areas of biotite, nearly black in color and 1 to 3 inches in diameter, occur.

Within the western limits of Gastonia flat-surface masses of the same granite are exposed. A single small opening has been made and a few feet of the surface stone quarried. Jointing is in two directions approximately N.-S., and E.-W.

About 1½ miles north of Gastonia several small openings have been worked recently, immediately along the Gastonia-Dallas macadam road. The rock is a biotite granite in all respects similar to that opened in the eastern and northern limits of the town, except that it is finer in texture. Joints penetrate in two directions, namely, N.-S., and N. 60°-70° W. The small amount of the stone quarried has been used for macadam purposes on the road along which it occurs.

Microscopical Examination.—Slides cut from hand specimens of the granite opened in the north and the east limits of the town of Gastonia, show a somewhat coarser textured granite than that opened 1½ miles north of the town, on the macadam road. Also more biotite is indicated in the thin sections of the latter rock, which in the hand specimen is correspondingly darker in color. The same features are developed megascopically in the granite of the two localities.

The rock is a biotite granite in which the potash feldspars, orthoclase and microcline, are present in nearly equal amount, except in the rock from the opening in the eastern limits of the town, the thin section of which shows orthoclase in excess of microcline. In several of the sections plagioclase failed entirely, while in the others only a few scattered finely striated grains were noted. Micrographic intergrowths of quartz and feldspar are rather freely developed in all the sections, indicating the overlapping of the periods of crystallization of the two minerals. Micropoikilitic structure and micropertitic intergrowths are indicated in each one of the sections.

Much secondary muscovite derived largely from the alteration of the feldspars is indicated in the thin sections in the form of both large shreds and minute scales in association with kaolin. Biotite is of the usual kind and is largely altered to chlorite, some epidote, and iron oxide. The usual microscopic inclusions of apatite and zircon occur.

THE BELL-PEYSOUR OPENINGS.

About $2\frac{1}{2}$ miles west of north from Gastonia and one-half mile west of the Gastonia-Dallas macadam road, is a granite ridge about 600 yards long trending about N. 30° E., and with an elevation of some 40 to 50 feet above the adjacent stream. A light gray variable textured biotite granite outcrops as flat-surface masses and boulders over the top of the ridge. At the south end and on top of the ridge the first raise over a large flat surface exposure of the granite was being worked up in August, 1903. The rock was being worked into shape for building an engine bed in one of the Gastonia cotton mills. The granite in this opening varies from a rather coarse to medium fine-textured rock with a like variation in color noted, according to the amount of biotite present. The entire raise indicated partially altered stone but with the next raise fresh granite may be expected. No veins are present in the granite and only one set of joints was observed penetrating the rock, striking N. 20° E. This opening is on the Bell place.

Microscopical Examination.—A thin section prepared from a hand specimen of the granite from the Bell opening indicated, microscopically, a larger proportion of microcline than orthoclase and scant plagioclase. The usual occurrence of micropertthite is noted. Micrographic intergrowths of quartz and feldspar are abundantly distributed through the slide. Biotite is greatly altered to chlorite and some epidote; and much muscovite, derived principally from the alteration of the feldspathic constituent, is present. The usual microscopical accessories occur.

The rock is essentially the same as that described above within the limits of the town of Gastonia, except that its texture and color are less uniform.

About 200 yards north of the Bell opening and on top of the same ridge a small opening was made some 12 or more years ago on the Rhodes place (known as the Peysour quarry) in a similar but smaller exposure of the granite. The rock is essentially the same as that described from the Bell opening except that a few small black segregation areas of biotite are present in places. A porphyritic tendency among the feldspathic constituent is developed in the granite of both openings. The few rock quarried from the Peysour opening are reported to have been used in part for trimmings in the court-house building at Dallas, and in part for monument bases.

Microscopical Examination.—Under the microscope a thin section of the granite from this opening indicates a finer textured rock than that from the Bell opening. Otherwise the mineral constituents of the two

granites are identical. Micrographic structure seems more abundant in the thin section of this rock than in the former one. Alteration products of the biotite are the same for the two rocks.

THE JENKINS QUARRY.

Two to $2\frac{1}{2}$ miles N. 60° W. of Gastonia, two openings one-quarter of a mile apart in an east-west direction, have been made in a porphyritic biotite-granite of medium-gray color and texture. At the west opening, which is the largest one, the exposure is crossed by a tiny stream. The rock is split into curbing 10 to 12 feet long for which it is principally used, although a few monument bases are reported to have been quarried. The rock indicates more or less of a schistose structure in a N. 10° E. direction along which it readily splits. Two sets of joints, spaced at wide intervals, cut the granite-mass striking N. 20° - 30° E., and N. 80° W.

The feldspar phenocrysts are rather sparingly distributed through the rock; both idiomorphic and allotriomorphic ones appear, the former exhibiting flat-tabular outlines and measuring two inches long by one-quarter to one-half inch across in the largest ones. The phenocrysts are further characterized by inclusions of large flecks or plates of the ground-mass biotite, and they have a faint pinkish tone.

Microscopical Examination.—Under the microscope a thin section of this granite shows the biotite arranged along somewhat parallel lines in the direction of the longer axis of the individual shreds, with some granulation from pressure effects of the other minerals noted. The mineral constituents are the same and they occur in about the same order of abundance as in the other granites noted above from Gaston County. Considerable finely striated plagioclase in long laths is distributed through the slide. Chlorite, a colorless mica, iron oxide, and some epidote occur as alteration products derived from the biotite. The large feldspar individuals show the micropoikilitic structure. The phenocrysts consist entirely of potash feldspar.

The granite on the Jenkins place is easy to quarry and it is an excellent stone for the uses made of it.

THE HOPE QUARRY.

About 3 miles northwest of Belmont, a station on the main line of the Southern Railway, exposures of a very desirable granite occur on both sides of a small stream. A small quantity of the stone has been quarried in a number of places. Recently an opening has been made in a flat-

surface outcrop of the rock on the northwest side of the Gaston-Charlotte road and about 200 yards distant from it.

The rock is a medium-textured, light gray with a pinkish tone biotite-granite and completely massive in structure. It bears a slight resemblance to the granite quarried at Dunns Mountain in Rowan County. Jointing is not conspicuous in the rock. Only one set of planes were observed, which showed a strike of N. 20° W. The joint-planes show slickensided surfaces. No veins nor injurious minerals occur in the rock. Very small and scattered segregated areas of biotite are developed in places through the rock, but these are not of large enough size nor sufficiently numerous to in anywise injure the granite.

The feldspars are colored a very faint pinkish tone, which imparts the barest mixed gray and pink color to the rock. It is a hard granite, quite lively in appearance and of uniform color and texture, and it should prove a very desirable stone for general building purposes.

Microscopical Examination.—Microscopically, the rock is a biotite granite in which orthoclase is in excess of microcline. Much finely striated acid plagioclase is distributed through the slide. Microperthite is in usual amount and Carlsbad twinning is observed to some extent among the potash feldspars. The feldspars are distributed through the section in large partially idiomorphic crystals, usually much altered into kaolin and small scales of muscovite. Biotite shows the usual alteration into chlorite and some epidote and other secondary products not positively identified. The rock as a whole is some coarser in texture than the other granites occurring in Gaston County and described above.

The granite mass is quite an extensive one, exposed over the area in the nature of large boulders and flat-surface masses. The Gaston-Charlotte road leading to Belmont Station traverses the area for a distance of not less than one mile. As a rule, the larger flat exposures require little or no stripping before working, there being in many cases practically no sap on the rock.

The granite quarried up to the present time has been used principally for foundations, sills and trimmings in buildings in the city of Charlotte, and for the same purpose in one of the buildings of Saint Mary's College, near Belmont.

Dikes of Basic Igneous Rocks.

At only 2 points within the granite area of Gaston County has dike material been observed. About 1½ miles northeast of Lowell Station on the main line of the Southern Railway, a dike of dioritic material crosses the Gastonia-Charlotte road. No fresh material could be

obtained at this point. Again to the southeast of Gastonia, near the large cotton mill, scattered boulders of diabase were noted along the road but they could not be located in place. These evidently indicate a dike of diabase nearby.

MECKLENBURG COUNTY.

Mecklenburg County contains an abundance of igneous rocks ranging in composition from the most acid to the most basic kinds. Granites and quartz-porphry (leopardite) among the acid, and diabase, diorite, lamprophyre and peridotites among the basic rocks are the principal types represented.

Although granite occurs very generally over the County, comparatively few quarries have yet been opened. For convenience of description the granite of this County may be treated under the following areas: The Charlotte area; The Morning Glade Church area; and, the Davidson area.

THE CHARLOTTE GRANITE AREA.

Under this heading are included all known granites within a radius of 5 or 6 miles of the city of Charlotte. Openings have been worked within the city limits of Charlotte; at several places about 4 miles east of the city; at several places 5 and 6 miles south of Charlotte; just beyond the southeast limits of the city; and at Belmont Springs, about 1½ miles east of the public square in Charlotte.

THE CITY QUARRY.

Near the freight depot in the southeast quarter of the city of Charlotte an extensive opening in a much crushed granite has been worked for many years to supply stone principally for macadamizing the streets, and for ballast. As nearly as could be determined, the opening is 350 feet by 400 feet at the top and has been worked to an average depth of 50 feet. The rock is too much crushed and jointed, and too variable in color and texture, to be used for any purpose except as road material and ballast. During August, 1903, stone was being quarried for macadamizing the city streets, for which the granite seems admirably suited. A crusher was in operation at the quarry for crushing and sizing the stone. Results of tests of this rock for road material are given on p. 266.

The rock is a hard and close-textured biotite granite, the average phase of which is fine-textured and of bluish gray color, manifesting in places much epidotization. It is penetrated at close intervals by 2 principal

sets of joints, which strike N. 40° E., and N. 35°-50° W., the surfaces of which are usually slickensided (see Fig. A, Pl. VII). In addition to the joints the rock is penetrated by a series of dark greenish, fine-grained schistose diabase dikes which range from 12 inches to several feet across. Quite a number of these dikes are exposed in the quarry cutting the rock at irregular intervals and coincident with the jointing whose strike is N. 40° E. The contacts between the granite and the basic eruptive are always clean cut and sharp (Fig. B, Pl. VII).

Microscopical Examination.—Under the microscope a thin section of the rock shows a biotite granite of a fine textured complexly interlocking aggregate of feldspar and quartz. Potash feldspars, orthoclase and microcline, and micropertthitic intergrowths, with very little plagioclase compose the feldspathic constituent. The biotite is irregularly distributed through the section in small shreds and largely altered. A few scattered grains of magnetite occur and the effects of dynamic-metamorphism are distinctly manifest.

A thin section of a specimen from one of the dikes of basic eruptive rock penetrating the granite in this quarry shows under the microscope a uraltic or altered diabase of very fine texture. The augite is altered to the usual form of hornblende and a little quartz is distributed through the section.

THE ORDERS QUARRY.

Just beyond the southeastern limits of the city of Charlotte, 2 small openings, made near together, have recently been worked for road macadam. The rock is quite similar to that described above from the City quarry. It varies in texture and composition, is bluish to greenish gray in color and is much crushed and intersected by close jointing. The strike of the joint-planes is N. 10° W., and N. 60° W., and their surfaces are typically slickensided. Much epidotization is in evidence in the rock at the openings. The rock can only be used for macadam and ballast, for which it seems well suited.

THE SNELL OPENING.

Four miles east of Charlotte, on the south side of the Charlotte-Monroe road on the Seaboard Air Line Railway, some granite has been quarried to a limited extent for road purposes. The rock outcrops in and along a small stream. It is a biotite-granite, quite variable in composition and texture, and is penetrated by a number of diabase dikes striking N.-S., N. 25° W., and N. 10° E. Both the enclosing granite



A. CITY QUARRY, CHARLOTTE, N. C., SHOWING DEVELOPMENT OF JOINTS PENETRATING THE GRANITE.



B. DIABASE DIKE PENETRATING GRANITE AT CITY QUARRY, CHARLOTTE, N. C.

sets of joints, which strike N. 40° E., and N. 35°-50° W., the surfaces of which are usually slickensided (see Fig. A, Pl. VII). In addition to the joints the rock is penetrated by a series of dark greenish, fine-grained schistose diabase dikes which range from 12 inches to several feet across. Quite a number of these dikes are exposed in the quarry cutting the rock at irregular intervals and coincident with the jointing whose strike is N. 40° E. The contacts between the granite and the basic eruptive are always clean cut and sharp (Fig. B, Pl. VII).

Microscopical Examination.—Under the microscope a thin section of the rock shows a biotite granite of a fine textured complexly interlocking aggregate of feldspar and quartz. Potash feldspars, orthoclase and microcline, and micropertthitic intergrowths, with very little plagioclase compose the feldspathic constituent. The biotite is irregularly distributed through the section in small shreds and largely altered. A few scattered grains of magnetite occur and the effects of dynamic-metamorphism are distinctly manifest.

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THE SNELL OPENING.

Four miles east of Charlotte, on the south side of the Charlotte-Monroe road on the Seaboard Air Line Railway, some granite has been quarried to a limited extent for road purposes. The rock outcrops in and along a small stream. It is a biotite-granite, quite variable in composition and texture, and is penetrated by a number of diabase dikes striking N.-S., N. 25° W., and N. 10° E. Both the enclosing granite

and the basic dike rocks are greatly crushed from pressure-metamorphism and are otherwise rendered schistose. The rock can only be used for macadam and ballast.

THE DUNN QUARRY.

About one mile west of the Snell opening and on the same stream, 2 small openings have been made in outcrops of a biotite granite, which is in every respect the same as that described above on the Snell place. The stone quarried is reported to have been used for macadam.

Two parallel dikes of diabase about 50 paces apart, trending N. 20° E., and less than 12 feet wide, intersect the crushed granite in this quarry. On the opposite side of the stream next to Mrs. Dunn's house, are outcrops of a dark holocrystalline eruptive which may possibly prove to be a facies of the granite.

THE SMITH QUARRY.

About 5 miles south of Charlotte and a quarter of a mile west of the Nation Ford road, boulder outcrops of a hornblende-biotite granite are exposed over an area of less than a dozen acres in extent. A number of small openings have been made in different places and some of the largest boulders have been partially worked off. The first quarrying was done some years ago when millstones are reported to have been quarried and used in the early ore-mills of the gold mines in Mecklenburg and the adjoining counties.

The rock is a medium-textured, uniformly blue-gray, hornblende-biotite granite of most pleasing appearance. Small segregations or bunches of the ferro-magnesian constituent, principally biotite, are distributed through some portions of the rock, but they are not sufficiently numerous nor large enough to detract from the good qualities of the stone. Occasional pyrite crystals are distributed through the rock, but this constituent does not appear in quantities large enough to in any wise injure the stone. The rock is perfectly massive in structure and blocks of almost any size can be quarried. It is a very desirable stone and it should prove to be admirably adapted to monumental purposes.

In addition to the mill stones mentioned above, the rock has been used for monumental stock and for building purposes in the city of Charlotte. The stone used in some of the older buildings in Charlotte show no visible effects of weathering and it is apparently quite as fresh as when it was first quarried. The rock is susceptible of a high polish and a number of monuments in the city cemetery in Charlotte are reported to have been fashioned from stone quarried at this locality.

Microscopical Examination.—Several thin sections cut from the rock at this locality showed microscopically, a hornblende-biotite-granite of medium texture, composed of the principal minerals feldspar, quartz, hornblende, and biotite with some minor accessories, including much titaniferous magnetite. Large stout laths of striated plagioclase, considerably altered, are freely distributed through the section with the principal potash feldspars. Biotite and hornblende show the usual alteration products, the principal one of which is chlorite. Much titaniferous magnetite occurs.

THE KIRKPATRICK OPENING.

About one mile southeast of the Smith Quarry, described above, on King's branch and about 6 miles south of Charlotte and a quarter of a mile southeast of the Nation Ford road, boulder outcrops of the same granite as that described from the Smith Quarry are exposed. One small opening was made several years ago to obtain rock for road purposes. In composition, texture and color the rock is identical with that quarried on the Smith place. It is, however, filled with segregations or bunches of the ferro-magnesian minerals of black color and fine grain, which vary in size from an inch to 6 inches and more in diameter. These segregations are so numerous in the rock at this point as to render the stone unfit for any purpose save that of rough grades of work.

In outline the segregation areas range from roughly oval-shaped forms to those very much elongated and they apparently observe orientation through the rock in the direction more or less parallel to their longer axis. Sharp contacts are observed between the segregation and the enclosing granite. A single slickensided joint-surface was noted.

THE CALDWELL PLACE.

About $3\frac{1}{4}$ miles northeast of Charlotte and about 100 paces to the right of the Concord road, a small opening has been made in an exposure of medium-textured gray biotite-granite. The opening is in a small ledge outcrop along a small stream. Joints intersect the rock in a general N. 40° W. direction, and it is further intersected by numerous thin seams and veins of pegmatitic composition. Several large inclusions of the country rock are exposed in the granite-mass.

Quartz-Porphyry (Leopardite).

The earliest published accounts of the aptly named leopardite in North Carolina appear in the *American Journal of Science* for the years 1853 and 1862. As early as the year 1853. Hunter, in a paper entitled "Notes

on the Rarer Minerals and New Localities in Western North Carolina" gives a brief description of the leopardite occurring east of Charlotte in Mecklenburg County, North Carolina. He says:²⁵

"It is noticed by Professor Shepard, under the head of feldspar, as the "Leopard Stone of Charlotte, North Carolina."

In this paper the author refers to a second locality where leopardite has been found in the State, namely, in Lincoln County.

In 1862 Doctor F. A. Genth, under the caption "Contributions to Mineralogy,"²⁶ published in the same journal, describes the leopardite as a true porphyry and gives the results of a microscopical examination together with a chemical analysis. Doctor Genth mentions a third locality in North Carolina where leopardite is found, namely, near the Steele mine, in Montgomery County.

In addition to these, the rock near Charlotte has been more recently noted by Merrill²⁷ and Lewis.²⁸ The former in his treatise on "Stones for Building and Decoration," where, after briefly describing the rock, a statement is made of its economic value. In connection with his work on Building Stones of North Carolina, Lewis visited the locality east of Charlotte where the leopardite occurs and was probably the first to note its true occurrence.

Location and Description.—The leopardite is exposed in a number of outcrops at Belmont Springs, $1\frac{1}{2}$ to $1\frac{3}{4}$ miles east of Charlotte. Beginning at a point on top of the hill, about 100 to 150 yards above the spring, the rock can be traced for a distance of from one-quarter to one-half mile in a N. 30° E. direction on the Phiher place, where the largest opening has been made. The leopardite forms a true dike intersecting a biotite-granite of much the same character as that described above at the Charlotte City quarry and on the Orders place. So far as it was possible to determine, the dike nowhere exceeds 25 feet in width and in places it is less. The contact with the enclosing granite is sharply defined at the opening on the Phiher place to the northeast of the spring.

In the fresh specimens the rock is nearly pure white, tinged the very faintest greenish tone in places, and penetrated by long parallel streaks or pencils of a dead black color. When the rock is broken at right angles

²⁵ Hunter, C. L., *Notices of the Rarer Minerals and New Localities in Western North Carolina*, Silliman's Journal, 1853 (2 S.), Vol. XV, p. 377.

²⁶ Genth, F. A., *Contributions to Mineralogy*, Amer. Journ. Science, 1862 (2 S.), Vol. XXXIII, pp. 197-198.

²⁷ Merrill, Geo. P., *Stones for Building and Decoration*, New York, 1897, 2d Edition, pp. 272-273.

²⁸ Lewis, J. V., *Notes on Building and Ornamental Stone*, 1st Biennial Report, N. C. Geol. Survey, 1898, p. 102.

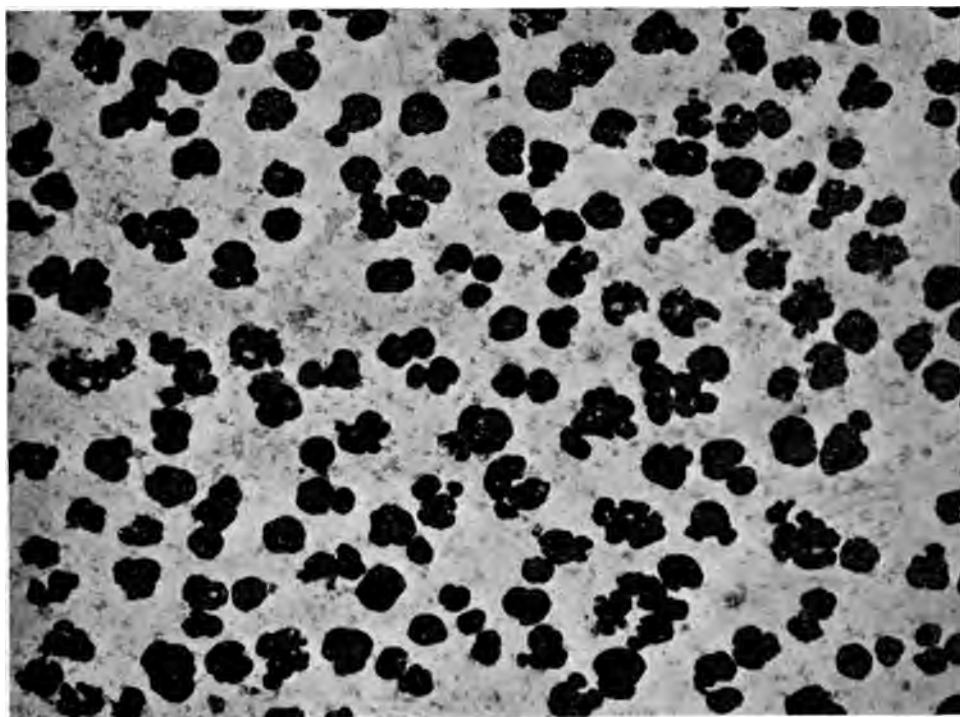
to these, the surface appears spotted with rounded irregular black points, ranging in size up to a half inch in diameter (Pl. VIII, Fig. A). A section cut parallel with the direction of the pencils presents a surface streaked with long somewhat irregular though roughly parallel black lines, assuming at times complete dendritic or fern-like forms (Pl. VIII, Fig. B.). At times the roundish points are somewhat irregular and are only partially developed, presenting a surface which roughly resembles the cuneiform surface of graphic granite. The pencils may be crowded uniformly close together over a surface as shown in Fig. A, Pl. VIII, or they may be entirely absent from some areas and irregularly distributed at wide intervals over others. Indeed the black pencils are reported to decrease and finally disappear in the rock as the dike is traced northward. Every outcrop and specimen of the rock, however, that was examined contained them. These black streaks or pencils are composed of the oxides of iron and manganese.

The rock is a dense and compact cryptocrystalline quartz-porphyry which breaks with a conchoidal fracture, and it is intensely hard and tough. Good specimens of it are well nigh impossible to obtain with the hammer but requires a shot to break them. Minute quartz crystals of perfect doubly terminated pyramidal faces are disseminated through the matrix. These are not abundant and are apt to be over-looked unless the rock is carefully scrutinized, but they are always present and are of both white and dark smoky vitreous quartz.

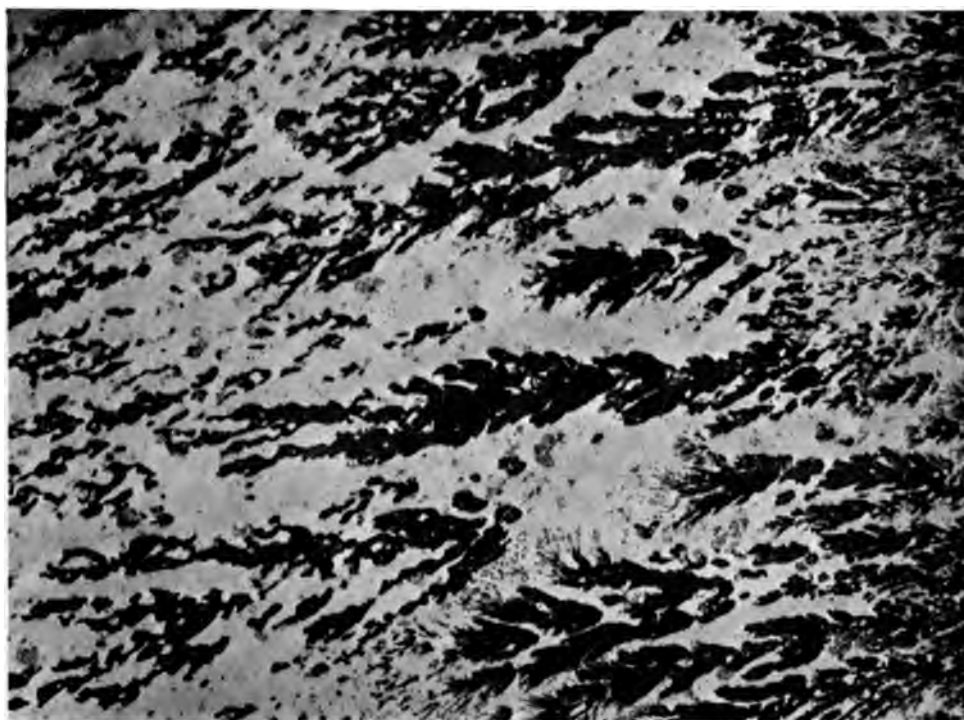
*Microscopical Examination.*²²—Microscopic study of sections of the rock shows an exceeding finely crystalline aggregate or groundmass of completely interlocking quartz and feldspar, through which is distributed a large proportion of irregular minute shreds of a colorless mica, probably muscovite. The mica has its greatest development along the sutures of the quartz and feldspar and is often found penetrating both of these minerals. It occurs in partially radiate tuft-like forms and in single and intergrown shreds.

Feldspar is the most abundant constituent in the rock and, so far as could be determined, it is composed of both potash and plagioclase species. Occasional grains of microcline are recognized which show the characteristic microcline twinning. Optical tests show the plagioclase to be albite, some of which exhibits polysynthetic twinning. Prismatic habit is strongly developed in much of the plagioclase, and the entire feldspar content is very generally clouded by innumerable inclusions, the exact nature of which it was not possible to determine.

²² The Leopardite (Quartz Porphyry) of North Carolina, by Thomas L. Watson, *Journal of Geology*, 1904, Vol. XII, pp. 215-224.



A. PHOTOGRAPH OF FRESH SURFACE OF LEOPARDITE SHOWING THE STONE WHEN BROKEN AT RIGHT ANGLES TO THE LONG PARALLEL STREAKS OR PENCILS OF A DEAD BLACK COLOR.



B. PHOTOGRAPH OF A SECTION OF THE LEOPARDITE CUT PARALLEL WITH THE DIRECTION OF THE PENCILS.

Quartz is the next most abundant mineral in the rock, forming minute irregular interlocking grains. Much of it is intergrown with the feldspar in micrographic structure, forming more or less rounded disk-like areas, some of which show quite distinctly under cross nicols a somewhat spherulitic tendency of distinct radiate structure. When they form complete spheres, which is rarely the case, they usually exhibit somewhat irregular ragged peripheries, and further show usually between cross nicols a very indefinite black cross. Other of the areas have much the same appearance as the similar structure in the normal granite.

Phenocrysts of both idiomorphic quartz and feldspar are distributed at wide intervals through the finely crystalline quartz-feldspar groundmass. In the hand specimens these are apt to be over-looked unless the rock is very carefully scrutinized. Under the microscope the phenocrysts appear as squarish sections of quartz and somewhat broad lath-shaped forms of feldspar. Both orthoclase and a broadly twinned acid plagioclase are developed porphyritically. Unlike the groundmass feldspar the porphyritic feldspars usually show more or less alteration into kaolin and muscovite.

Several of the thin sections were so cut as to include areas of the black pencils shown in the hand specimens. These are distinguished microscopically from the white portions of the groundmass only by a distinct medium to dark yellowish brown staining which closely resembles that of limonite, such as is often observed in the partial leaching of an iron-bearing mineral in igneous rocks. No definite source from which this staining was derived was entirely indicated in any of the sections, but that they represent percolation of iron and manganese solutions through the rock scarcely admits of reasonable doubt. Why the definite arrangement into long pencils and dendritic forms manifested megascopically, evidence is again lacking, for the textural conditions and relations of the minerals in the areas are precisely the same as for other portions of the rock. Microscopic study suggests the probability that the penciled structure of the rock will prove not to be uniform throughout the entire rock-mass, but probably characterizes only certain portions of it.

The dust-like inclusions in the feldspars mentioned above may possibly prove to be the free oxides of iron and manganese from which the staining is derived forming the areas, but the examination of the slides does not seem to indicate such a source.

The following is a chemical analysis of carefully selected pieces of the leopardite matrix made by Doctor F. A. Genth: ²⁰

²⁰ Genth, F. A., *Amer. Journ. Sci.*, 1862 (2 S.), Vol. XXXIII, p. 198.

Analysis of Leopardite.

SiO ₂	75.92
Al ₂ O ₃	14.47
Fe ₂ O ₃	0.88
MgO	0.09
CaO	0.02
Na ₂ O	4.98
K ₂ O	4.01
Ignition	0.64
Total	100.01

The most noteworthy features of the analysis are the nearly complete absence of lime and the slightly increased amount of soda over potash, circumstances which would seemingly indicate the lack of any one of the lime-bearing plagioclase species and that much of the feldspar is composed of anorthoclase and orthoclase. This conclusion is fully confirmed by the microscopic study.

In the weathered outcrops, which are still hard and firm rock, the matrix presents an opaque lusterless dead chalk-like whiteness and the pencils are bleached to some extent, and changed from a black to a slightly reddish-brown color.

The rock is without definite rift but it shows some jointing which fact, coupled with its exceeding hardness and toughness, would make the stone an expensive one to quarry. The slight openings already made were to obtain stone for local use and to some extent for the procuring of museum specimens. The rock is susceptible of an excellent polish and it could be used to splendid effect in inlaid work. Specimens in both the rough and polished state, including a carved figure of a leopard, are on exhibit in the building stone collection in the State Museum at Raleigh. The stone is probably too brittle to yield good results in carving. It has been used in a very small way locally for curbing, steps and sills.

THE MORNING GLADE CHURCH AREA.

This name is given to a granite area in the vicinity of Morning Glade Church on the Fayetteville Road, a few miles east of the Mecklenburg-Cabarrus county line and about 4 miles east of south of Newells, a station on the main line of the Southern Railway. The area is further located about 10 miles slightly north of east from Charlotte. The granite is best exposed on the Cross place, in the form of immense boulder outcrops, several of which have been split and a few stone quarried for bridge work.

THE CROSS PLACE.

About 10 miles east from Charlotte and near the Cross dwelling house, are large boulder outcrops of a light gray biotite-granite exposed over a considerable area. The largest boulders will measure from 20 to 30 feet high and they are proportionately large in other dimensions. One of the largest boulders has been split and nearly worked up into stone for piers in the construction of a bridge nearby on the Fayetteville road.

The rock is a medium-textured massive granite but, as indicated from the large boulder that is nearly worked up, is partially decayed throughout. The feldspars are more or less kaolinized and the biotite shows alteration and leaching in the staining of the decayed rock from the liberated iron oxide. In the fresher portions of the rock the biotite has apparently suffered more from decay than the feldspars. Some of the feldspars are nearly entirely fresh while the biotite in the same areas of the rock shows considerable leaching of the liberated iron oxide, discoloring the rock. The fresh granite should be encountered at a very moderate depth below the decay, which judging from the character of the boulders should prove to be a desirable stone for general building purposes.

The bouldery outcrops form an elevated ridge back some little distance from a small stream and at some elevation above the water level. The location is a very favorable one for quarrying.

THE DAVIDSON GRANITE AREA.

This area is named for the principal town, Davidson, occurring within the limits of the area. The town is located on the Charlotte-Winston Branch of the Southern Railway, in the extreme northern part of Mecklenburg County and only a few miles south of the Iredell County line. The area includes all the granites occurring in the northern portion of Mecklenburg County. It extends northward into Iredell County, the limits of which include nearly the entire southern portion of the County, and to some distance north of Mooresville. It should more properly be designated the Davidson-Mooresville area, since no geographic boundary can be drawn between the 2 counties that would separate the area, but since the method of treatment in this report is by counties, it is thought best to divide it into the Davidson area in Mecklenburg County, and the Mooresville area in Iredell County.

One distinction can be drawn, however, between the subdivisions of the area here made, which is that in the Mooresville part of the area, the main body of the granite is typically porphyritic, identical with that

described to the north of Gastonia, in Gaston County. Over the Davidson area to the south in Mecklenburg County, the rock is an even-granular granite, hornblende-bearing in places, a feature not observed in the northern part of the area around Mooresville.

Numerous small openings to the east, south, and southwest of Davidson have been made at different times in Mecklenburg County to obtain stone for local use, but no regular quarries have been worked.

One-half mile east of Davidson, immediately on the north side of the macadam road, a few partially decayed granite boulders exposed in the residual decay of the granite have been worked recently for road material. The opening extends a slight depth below the boulders into the decayed rock. The decay is quite deep and is of the characteristic gray and red colors shown in the earlier and more advanced stages of granite-weathering.

The rock is a fine textured, light gray, biotite-granite, which can be utilized to advantage in many of the lower grades of work in which granite is used.

Microscopical Examination.—Under the microscope a thin section of the rock showed a biotite granite of medium-fine texture, composed of an aggregate of potash and some plagioclase feldspars, quartz, and biotite. Biotite shows the usual alteration. Several small grains of pyrite were scattered through the section, but pyrite was not observed by the unaided eye in the hand specimen. Effects of crushing and recrystallization from dynamic forces are indicated. A few areas of micrographic intergrowths of quartz and feldspar are shown and micropoikilitic structure is more or less well developed.

A short distance below the opening, exposed along the roadside, is a small dike of diabase penetrating the granite. The exposure is in a section of granite decay.

THE CALDWELL PLACE.

One mile east of Davidson and about a quarter of a mile south of the macadam road are somewhat extensive boulder and ledge outcrops of a very desirable granite, exposed along a small stream just below the Caldwell dwelling-house. The rock is exposed over the wooded slopes on the 2 sides of the stream and extends over not less than 50 to 60 acres of surface. Some of the surface stone was quarried many years ago in an exposure of the rock just above the stream and used for foundations in several of the buildings of Davidson College.

The rock is a biotite-bearing hornblende-granite of medium texture and medium-gray color, intensely hard and tough and lively in appear-

ance. After some testing it was reported that the rock was found to be too hard for crushing and mixing in the rock-crushers. The hornblende is greenish-black in color and it is distributed through the rock in the form of irregular grains and lath-shaped idiomorphic crystals, measuring in extreme cases as much as $1\frac{1}{4}$ inches long by a quarter of an inch wide.

Two sets of joint-planes intersect the granite striking N. 20° W., and N. 70° E. Many areas of hornblende-biotite segregations of dark color and irregular outline measuring from 2 to 10 inches long by 1 to 3 inches across, are quite freely distributed through the rock in places. Good dimension stone, however, free from the dark segregation areas can be quarried. Altogether the rock is a pleasing one in both color and texture which in connection with its other good qualities make it an admirably suited stone for general building and other purposes.

Microscopical Examination.—Thin sections of the rock show striated plagioclase in excess of the potash species with beautiful zonary structure developed in them: quartz, biotite, hornblende, and some magnetite. Plagioclase is distributed through the sections in large stout laths. No injurious minerals were noted in the thin sections. A little chlorite and epidote occur as alteration products.

THE HARRIET SLOAN MILL PLACE.

On the west fork of Rocky River, about 5 miles east of Davidson are immense boulder outcrops of a medium fine-textured, gray, biotite-granite exposed partly in Mecklenburg and partly in Cabarrus counties. The exposures are traced for some distance on both sides of the stream, but on the east side in Cabarrus County, the boulders are of huge dimensions and extend over the top and slope of a ridge which rises to some elevation above the level of the stream and covering more than 200 acres of surface. The exposures are reported to be more or less continuous over an area of several miles extent in this part of Cabarrus County.

Prior to the Civil War, when the early buildings of Davidson College were being constructed, the foundations, steps, and sills were quarried from one of the larger boulders exposed on the ridge slope in Cabarrus County. No recent openings have been made in the rock at any point. The outer portions of the boulders consist of hard and firm though partially decayed rock, the feldspars of which are more or less dull and without lustre from alteration and the biotite is somewhat altered, discoloring the rock with the liberated iron oxide. This form of decay extends inward from the surface of the rock for some distance. Although the buildings on the college campus at Davidson in which the granite was used were erected about 1860, the weathering effects appear to be no more

appreciable than when the stone was first quarried. The rock used was from the surface and did not represent the entirely fresh granite.

The granite exhibits good working qualities in the natural exposures and it is in all respects an excellent stone, well suited for most purposes for which granite is used.

Microscopical Examination.—A thin section cut from as fresh a specimen of the rock as it was possible to obtain showed microscopically a biotite granite of medium texture. The principal minerals were orthoclase, microcline, much plagioclase, quartz, biotite, titanite, titaniferous magnetite, altered peripherally or rimmed by the usual colorless titanium mineral, epidote, and chlorite. Both the feldspars and biotite contain inclusions and some evidence of the effects of dynamic forces are indicated in the section. No injurious or harmful minerals are present.

THE KNOX QUARRY.


One and three-quarter miles S. 70° W. of Davidson an exposure of granite was being worked during the summer of 1903 by blasting, and the quarried stone was being used for macadamizing the roads in the vicinity of Davidson. The rock is a medium-textured, moderately light to dark gray biotite-granite of entirely massive structure but intersected by close jointing and is lacking in uniform color and texture.

Four sets of joints intersect the granite mass at close intervals, striking N.-S., E.-W., N. 20° E., and N. 45° W. Most of the joint-plane surfaces are slickensided as a result of subsequent movement in the granite-mass. The rock is soft from partial alteration for the entire depth of the opening, 12 feet. Several feet of the gray and red residual granite decay covers the hard granite which must be stripped before working. The rock is unsuited for any purpose except for the rougher grades of work.

Microscopical Examination.—A thin section cut from a specimen of the rock collected 3 miles southwest of Davidson on the new macadam road showed microscopically a biotite granite composed of quartz, potash and plagioclase feldspars, and biotite. The biotite is largely altered to chlorite and epidote. Prismatic inclusions of apatite are rather abundant in the feldspars. No harmful minerals occur in the section.

THE BLAKELY QUARRY.

One mile southwest of Davidson, two small openings have been made in exposures of a medium-textured, light gray, biotite-granite to obtain stone for macadamizing the roads in the vicinity. The openings are in



a northwest-southeast alignment, about a quarter of a mile apart, and will average about 25 yards square, worked to a depth not exceeding 8 or 10 feet.

The biotite occupies well defined areas in the rock in the form of minute groups or bunches of aggregated intergrown shreds, which impart somewhat of a mottled appearance to the granite. The largest of the areas will not exceed an eighth of an inch in diameter.

Decay of the Granite.—Over most of the Davidson area the granite is deeply weathered, yielding a characteristic light-gray sandy to red gritty clay. The roads which lead in all directions from Davidson crossing the granite, show typical sections of shallow depth of the granite decay. Especially favorable were the conditions along the road that was being graded and macadamized during the summer of 1903, southwest from the town. Sections of the granite decay, 10, 20, and 30 feet in depth were numerous along this road for a distance of several miles from Davidson, and in every case examined the decay represented an advanced stage of weathering. In much of it none of the original minerals are identified, megascopically, but they have been apparently completely altered into the usual by-products. In other parts of the decay the stage of weathering is less far advanced and the original minerals are easy of determination by the unaided eye.

Dikes of Basic Intrusive Rocks.

Intrusive dikes of basic composition, including principally diabase and diorite and their altered equivalents, have rather wide distribution over nearly all parts of Mecklenburg County, that were studied. It is regretted that the time available for the preparation of this report does not permit of a petrographic description of this class of igneous rocks, but the material will be studied and reported on later. For the present it is only possible to briefly mention these rocks under each county in which they have been noted.

Between the main line of the Southern Railway and the Pineville road on the Smith place, 4 miles south of Charlotte are large piled masses of boulders and smaller fragments of basic eruptive rocks of many different types. Corresponding types of these rocks were observed in place at a number of points along the road farther south, which can be utilized for various purposes, especially for road macadam.

Dikes of diabase have been noted at the following points to the east and southeast of Charlotte, which cut the granite in many cases: At the intersection of Lawyers' road and Seventh street; in the city limits

near the intersection of Seventh street by Pine; near the crossing of the stream by road leading to Belmont Springs, one mile east of Charlotte; the City granite quarry, near the freight depot; and at the Orders quarry just beyond the southeast limits of the city.

Dikes of basic igneous rocks have been noted at the following points along the Fayetteville and Concord roads between Charlotte and the county line, in a general northeast direction from Charlotte: Two and a half miles northeast of Charlotte on the Concord road; $3\frac{1}{4}$ miles northeast of Charlotte on the same road; and 5 miles northeast of Charlotte; 7 miles northeast of Charlotte on the Rocky River road, on the Alexander and Orr places; 2 miles north of Newell's Station on the same road; $2\frac{1}{2}$ miles north of Newell's Station on the same road; in cut of the Southern Railway 12 miles northeast of Charlotte; $8\frac{1}{2}$ miles northeast of Charlotte on the Stegall place; on the Fayetteville road between Morning Glade Church 12 miles northeast of Charlotte to within $8\frac{1}{2}$ miles of the city.

In the northern part of the County along the Concord road, leading east from Davidson, between Davidson and the county line, several dikes of diabase were observed penetrating the granite. Also southwest of Davidson, $1\frac{1}{4}$ miles along the newly graded macadam road a large dike of diabase penetrates the granite.

IREDELL COUNTY.

The granite area described above in the northern part of Mecklenburg County under the Davidson area forms the southward extension of a very extensive area covering the southern part of Iredell County. The granite is exposed in numerous outcrops in and about Mooresville, 6 to 8 miles north of Davidson, where a number of quarries have been worked. Unlike the southern portion of the area exposed around Davidson in the northern part of Mecklenburg County, the Iredell area exhibits 2 typical phases of the rock, namely, fine, even-granular and porphyritic in texture. The relations between these two phases of the granite are fully discussed below. The presence of hornblende in a part of the granite to the east of Davidson has not been observed in any part of the Iredell area, but biotite forms at all times the characterizing accessory in every outcrop of the granite examined in this part of the County.

Both the even-granular and the porphyritic granite are traced northward from Mooresville to Barium Springs, a station on the Charlotte-Statesville branch of the Southern Railway, 12 miles north of Mooresville and 4 miles south of Statesville. Many of the outcrops of the granite around Barium Springs show a decided schistose structure, a fea-

ture entirely absent from the Mooresville area, but is similarly shown in some of the outcrops to the southwest of Davidson, in Mecklenburg County.

Between Barium Springs and Statesville, the country-rock is typical mica-schist grading, in places, through increased quartz, into a quartz-micaceous-schist penetrated by large and small veins of white crystalline quartz. The schist is more or less feldspathic and is at all times deeply decayed, yielding a deep-red soil, and preserving in a remarkable degree the schistosity planes of the fresh rock, in many sections of the decay examined along the roads. No contacts between the granite and schist were observed, due likely to the lack of exposure of the fresh or moderately fresh rock, where contacts, should they be present, would be expected.

THE MOORESVILLE GRANITE AREA.

The Even-Grained Granite.

A number of quarries, opened in the even-granular granite have been worked principally for monumental stock, within several miles of the town of Mooresville. The monument in the Raleigh cemetery, marking the grave of former State Geologist, Professor W. C. Kerr, is from the Mooresville granite. Eight inch cubes, in the rough, hammer dressed and polished faces are among the building stone collections in the State Museum at Raleigh.

THE MCNEELY QUARRY.

One mile N. 70° W. of Mooresville several small openings have been made along a line of flat boulder outcrops, traced perhaps over a half-dozen acres of surface. The openings are all small and have not been worked to a depth exceeding 6 or 8 feet. Only one set of visible joints penetrate the granite in these openings, striking N. 65° W. A few knife-edge seams of feldspar intersect the granite in places. Biotite manifests a tendency to segregate in minute blotches containing several shreds to the area, similar to that in the Oglesby blue granite in Elbert County, Georgia, which is regarded as a very superior monumental granite. In general appearance the 2 granites bear a strikingly close resemblance to each other. No minerals, such as free sulphides and oxides, likely to cause discoloration on exposure of the rock were visible megascopically.

The rock is a fine-grained, dark blue-gray, biotite-granite of good quality. Excepting the very small blotches of biotite, which do not ex-

ceed several millimeters across nor in anywise detract from the good qualities of the stone, the biotite is evenly distributed through the granite and imparts a very uniform color throughout. The granite is also equally uniform in texture and it is entirely massive.

Microscopical Examination.—Microscopic study of a thin section of the rock from this quarry shows a fine-textured biotite granite, composed of orthoclase, microcline and microperthitic intergrowths, a sprinkling of stout laths of striated acid plagioclase, quartz, biotite, titanite, apatite, zircon, chlorite, and epidote.

Feldspar, including microperthite and a little plagioclase, is the most abundant constituent. Biotite is distributed rather uniformly in large amount through the section in the form of shreds and elongated plates of the usual color and absorption, and is partly altered to chlorite and a little epidote. Titanite of strong pleochroism and in complete idiomorphic and granular form is present in large quantity. A rather unusually large distribution of quartz-feldspar intergrowths as micrographic structure occurs, indicating simultaneous crystallization of the quartz with a part of the feldspar.

The small amount of the stone quarried is reported to have been used exclusively for monumental stock. In addition to the uniform color and texture, the stone shows strong contrast between the cut and polished surfaces, an essential feature in a high grade monumental granite.

This massive fine-grained, even-granular granite cuts the porphyritic granite, and good sharp contacts between the two texturally unlike granites are found in a number of places near the openings in the decayed products of the 2 rocks. The nature of the contacts indicate that the 2 granites are not phases of the same rock, but that they are separate intrusions. Near the west opening a diabase dike less than 6 feet across penetrates the porphyritic granite, striking in a general northwest direction.

THE BREED QUARRY.

One and a half to 2 miles southwest of Mooresville, two openings, one-fourth mile apart in an east-west direction, have been worked in outcrops of granite similar to that of the McNeely quarry. The east opening, which is the largest one and was formerly known as the Breed quarry proper, has been worked at intervals on a small scale since first opened in 1886. The opening is made in a ledge outcrop along a small branch at the foot of a moderate hill-slope, the top of which rises probably 20 to 25 feet higher in elevation. In places the working has extended below the level of the stream. Along the surface the exposure



A. THE BREED QUARRY, $1\frac{1}{2}$ MILES SOUTHWEST OF MOORESVILLE, IREDELL COUNTY.



B. BOULDER OUTCROP OF AUGITE-SYENITE, 4 MILES SOUTHWEST OF CONCORD, CABARRUS COUNTY.

is more or less bouldery in character and in order to obtain dimension stone of fresh quality, stripping to a depth of 8 or 10 feet is necessary. It has been opened for a distance of about 200 feet along the ledge direction, and the quarrying has extended into the hill-slope for a distance of about 50 feet exposing a quarry-face of about 35 feet in depth. The face is not an even, smooth one, but it is much broken and ragged in outline, due probably more to the method of quarrying than to any natural condition of the rock.

About midway of the length of the opening the face exposes a zone not less than 30 feet wide of very close jointing, from which dimension stone can not be quarried. At any other point along the opening, stone of any dimension can be readily obtained (see Fig. A, Pl. IX).

Three sets of joints intersect the rock in the opening, striking E.-W., N.-S., and NW.-SE., the latter set being less prominent than the first two. In addition to the vertical joints, the stone is broken into nearly horizontal layers 3 to 8 feet thick. The vertical jointing is usually spaced at wide intervals, 18 to 20 feet and more, which admits of stone being blocked out of this length and of the thickness mentioned above.

The rock is a fine-grained, dark blue-gray biotite-granite of uniform texture and color. Hand specimens of the rock can not be distinguished from that of the McNeely quarry. It is rather a hard granite but it is reported to work well and it takes an excellent polish. It is in every respect a very desirable granite for monumental purposes for which it has been used.

Microscopical Examination.—Microscopically, the rock is a fine-textured biotite-granite identical with that described above from the McNeely quarry. Orthoclase and microcline are in nearly equal proportion, with only 1 or 2 grains of plagioclase noted in the section. Biotite of deep brown color and strong pleochroism is present in large quantity, largely altered to chlorite and a colorless mica. Micrographic intergrowths of quartz and feldspar are very much less abundant than in the granite from the McNeely quarry. A little epidote, pleochroic titanite, and large numbers of inclusions of apatite are noted.

A spur track was laid from the main line near Mooresville to the quarry for handling the stone. The granite has been shipped to various points in the State for use as monuments.

The west opening was made some years later than the east one, about 1891, or '92, and was then known as the Johnson quarry, but it has been subsequently purchased by the Charlotte Granite Company. The conditions at this opening are favorable to quarrying on a large scale. The

rock is identical with that from the east opening except that the biotite indicates the same tendency to segregation in minute areas similar to that in the McNeely quarry, imparting a slightly speckled appearance to the granite.

The following is a chemical analysis of the granite from the west (Johnson) opening:²⁷

Analysis of granite from near Johnson Opening.

	I.	II.
SiO ₂	66.01	69.53
Al ₂ O ₃	17.44	16.46
Fe ₂ O ₃	5.62	1.15
MnO ₂	0.23	....
CaO	1.44	2.19
MgO	1.11	0.85
Na ₂ O	5.06	5.00
K ₂ O	3.16	4.91
Loss on ignition.....	None	0.91
Total	100.07	100.91

I. Analysis of granite from the west opening, 1½ to 2 miles southwest of Mooresville, Iredell County, North Carolina.

II. Analysis of granite from the Diamond Blue Granite Company's Quarry, Oglethorpe County, Georgia. Thomas L. Watson, analyst.

The resemblance of the Mooresville granite to the Ogleby dark blue-gray granite in Elbert and Oglethorpe counties, Georgia, has already been remarked on. In order to make clearer this relationship between the 2 rocks, an analysis of the Georgia rock is given in column II²⁸ for comparison with that of the Carolina rock in column I.

Beautiful contacts between the fresh, fine-grained granite and the fresh porphyritic granite occur at the east opening, the description and nature of which are given below under the porphyritic granite, where the relations between the two rocks are discussed.

THE BIDDELL QUARRY.

Three miles N. 30° E. from Mooresville and one-quarter of a mile north of the Mooresville-Salisbury road, several small openings were made in 1891 in exposures of a similar granite to that described above under the McNeely and Breed quarries. The rock is reported to have

²⁷ Lewis, J. V., Notes on Building and Ornamental Stone, First Biennial Report, N. C. Geol. Survey, 1891-92 (1893), p. 87.

²⁸ Watson, Thomas L., A Preliminary Report on the Granites and Gneisses of Georgia, Georgia Geol. Survey, Bull. No. 9A, 1902, p. 191.

been worked for building stone which was shipped to the Pennsylvania markets. The openings are in a ledge outcrop exposed along a small branch at the foot of a long but gentle hill-slope. Large boulder outcrops of the granite are found some distance back from the stream on both sides, and they were traced along the branch for a considerable distance. The principal opening is in a ledge which rises 15 to 25 feet above the water-level in the branch and it is 150 feet long by 15 feet deep.

Jointing is spaced at wide intervals of which there are 2 sets striking N.-S., and N. 65° E. Small segregation veins and dikes of pegmatite, composed of white and pink feldspars, large plates of biotite, and some quartz, are numerous. These intersecting materials vary from one inch to more than 12 inches across and they cut the granite indiscriminately. Frequently they are found crossing each other, and hardly a block of any size of the stone that has been quarried is entirely exempt from them. For this reason the stone is restricted in its use, but in all other respects it should prove to be desirable for all purposes to which granite is usually put. It is quite possible that openings made in outcrops of the granite in other parts of the same area would yield dimension stone free from the intersecting materials.

The rock in the opening is a medium blue-gray granite, and is the same rock as that in the McNeely and Breed quarries. It varies in texture from medium to fine-grained and the slight speckled appearance due to the biotite exhibiting a tendency to segregate in minute blotches or areas is apparent. An additional wavy appearance of light and darker-colored streaks due to increased or diminished biotite, blending into each other, appear, in places, through the stone.

Microscopical Examination.—A thin section of the rock from this quarry shows, microscopically, a fine-textured biotite-granite composed of an aggregate of intricately interlocking quartz and feldspar, in which lie considerable shreds of biotite. Microcline is the predominant feldspar with some orthoclase and a little striated plagioclase, all of which contain more or less inclusions of prismatic apatite. Biotite has its usual distribution, color, and absorption, and it is altered to both chlorite and epidote. Micrographic intergrowths of the quartz and feldspar are developed through the section. A few small grains of magnetite occur. The rock is in all respects the same as that described from the McNeely and Breed quarries above.

The porphyritic granite extends several miles further in a northward direction along the Mooresville-Salisbury road, and it is of the same character as that exposed around Mooresville and Mount Mourne.

THE COTTON MILL OUTCROP.

Near the cotton mill in the southern limits of Mooresville, the fine-grained granite is exposed in several large boulders along the railroad and the main street. The rock is uniform in color and texture and is identical with that described in the Breed and McNeely quarries.

The Porphyritic Granite.

The porphyritic granite constitutes the main body of the rock in the Mooresville area. It is traced east of north from Mooresville along the Salisbury road for a distance of about 5 miles. To the south, southwest and west of Mooresville, it has been traced for a distance of approximately 3 miles in each direction. The rock is exposed in a number of large flat-surface outcrops in the vicinity of Mount Mourne, a station on the Southern Railway, $2\frac{1}{2}$ miles south of Mooresville. Over the entire area the porphyritic granite maintains remarkable uniformity in both color and texture.

Where exposed, the groundmass of the granite is medium coarse grained and dark gray in color from the presence of much biotite. It is composed of the essential minerals quartz, feldspar, and biotite.

The phenocrysts are composed of potash feldspar, usually twinned after the Carlsbad law. They are largely flat-tabular, idiomorphic in outline, ranging from $\frac{1}{2}$ to 2 inches in length by $\frac{1}{8}$ to $\frac{3}{8}$ of an inch across and are either white or pink in color. As a rule, the phenocrysts do not grade into the same constituent of the groundmass, but they are in most cases conspicuously developed and are sharply defined from the groundmass feldspar. Usually no marked orientation is observed in the phenocrysts, but at several exposures a slight tendency toward such was somewhat apparent. In every exposure of the porphyritic granite examined the phenocrysts showed more or less included biotite of the groundmass, and frequently as large in size. The ratio of the phenocrysts to the groundmass is approximately one to one, with but little variation from this in any of the outcrops examined.

In the fresh rock the phenocrysts are often of a pronounced pinkish color, but in the weathered granite they are entirely white and opaque from partial kaolinization. Over much of the area the granite is more or less deeply decayed and in sections of the decay the phenocrysts occupy their original positions in it as in the fresh rock. In such they are usually white and unstained, and with the loose scattered ones over the surface they afford an easy means of readily tracing the underlying fresh granite. Some sections in the decayed rock indicate weathering of the

rock into thin layers affording the appearance of a pronounced gneissic structure.

The best exposures of the fresh porphyritic granite are found about one-half mile north of Mount Mourne and at the Breed quarry $1\frac{1}{2}$ to 2 miles southwest of Mooresville. Outcrops of the partially or completely decayed rock are rather numerous over the entire area.

THE MOUNT MOURNE EXPOSURE.

One-half mile north of the station and 200 to 300 yards west of the railroad, a flat-surface exposure of the porphyritic granite known as "Flat-rock" occurs of about one acre in extent, from which some of the surface stone was quarried prior to the Civil War for foundations in some of the buildings of Davidson College. The rock as a whole exhibits the same characteristics as in the general description given above of the entire area. Both phenocryst and groundmass conform to this description.

At this point the porphyritic granite is cut by a dike of fine-textured dark blue-gray biotite granite similar to that in the McNeely and Breed quarries. The dike is quite irregular in outline, varying from 6 to 12 inches across, with a general northeast strike, and it is regarded as an apophysis from the main body of the same dark blue-gray granite. Small stringers or fingers given off from the dike penetrate the porphyritic granite, and at several places near the contact, the porphyritic granite is included in the dike as small irregular areas.

Microscopical Examination.—A thin section of the rock from this opening examined under the microscope shows a medium-textured porphyritic biotite-granite composed of microcline, a little orthoclase, and some striated plagioclase, quartz and biotite. Microcline is porphyritically developed and exhibits the micropoikilitic structure. Micrographic intergrowths of the quartz and feldspar are freely distributed through the section. Biotite has its usual distribution, color, and absorption, and it is closely associated with deep brown strongly pleochroic titanite and some epidote. Both the biotite and titanite contain inclusions, among which are apatite and magnetite. Apatite inclusions are also characteristic to some extent of the feldspar constituent.

Nature of the Contact at the Breed Quarry.—The contact here is between the fresh rock of the 2 granites and it affords an excellent opportunity for study of the relations between them. Here as at other points over the area the contact between the two rocks is entirely sharp and well defined. The texture of the porphyritic rock is well emphasized and of typical development. The phenocrysts are pink in color con-

forming in all other particulars to the general description above. The groundmass is dark-gray in color and medium coarse-grained in texture. It is uniformly coarser grained than the even-granular granite with which it forms the contact.

Frequent inclusions of the porphyritic granite of irregular outline and in size ranging from very small areas one and more inches in diameter to those several feet across are found in the even-granular granite, here and along the contact. These areas are sharply defined from the host. Near many of the included porphyritic granite areas in the even-granular granite numerous segregated areas of the biotite are formed in the latter rock. These are usually of irregular outline and small in size, measuring 3 to 4 inches long by 1 to 2 inches across and fail entirely at some distance away from the contact. More or less pronounced banding, differentiation of the light and dark minerals into parallel layers, is only observed along the contact between the two rocks.

Microscopical Examination of the Porphyritic Granite.—Under the microscope a thin section of the rock from near the Breed quarry shows a porphyritic biotite granite of medium texture. The groundmass consists of orthoclase and microperthitic intergrowths, a little striated feldspar, quartz, biotite, and much titanite. Intergrowths of quartz and feldspar in micrographic structure together with the usual inclusions of apatite and zircon, occur. Biotite is more or less altered to chlorite and a little epidote. The biotite is closely associated with titanite which occurs in the form of crystals and grains of marked pleochroism and cleavage, and filled with minute grains of black oxide of iron.

Microcline and microperthite compose the phenocrysts which strongly exhibit micropoikilitic structure, the inclusions of which are both potash and plagioclase feldspars, quartz, and biotite. Microcline fails entirely in the groundmass. It will be observed from the microscopic descriptions of the porphyritic and the even-granular granites at the Breed quarry that they only differ texturally, with essentially the same mineral composition.

RELATIONS OF THE GRANITES IN THE MOORESVILLE AREA.

From the general description of the even-granular and the porphyritic granites described above, and the nature of the contact where observed between the 2 rocks, it is reasonably conclusive that the 2 granites do not represent different facies of the same rock. Were this true the line between the 2 rocks should mark a zone of more or less transition from the porphyritic to the even-granular rock and not as in every case

observed indicate a sharp contact. Furthermore, certain phenomena developed along this line would be difficult of explanation on this supposition. On the other hand the evidence strongly supports the argument that the porphyritic rock is the oldest and that the even-granular granite is intrusive in it. The sharpness of contact; the prevailing coarser texture of the porphyritic granite than that of the even-granular granite along the contact; the banding in places along the contact, and inclusions of the porphyritic granite in the even-granular granite; and the occurrence of probable apophyses of the fine-grained rock penetrating the porphyritic granite, certainly support this belief.

It is true that the two granites only differ from each other in texture, both having the same mineral composition and in general necessarily closely similar chemical composition, a feature often observed in separate facies of the same granite mass.

THE BARIUM SPRINGS GRANITE AREA.

To the west of the depot and at the Springs proper, three small openings, near together, have been made in a porphyritic granite. These were made many years ago to obtain stone for bridge construction over the County.

The rock is quite variable in texture and in color, ranging from a fine-textured dark gray biotite to a medium-fine to coarse-grained porphyritic granite of light gray color. The porphyritic phase of the rock is more or less schistose in places. The phenocrysts are usually irregular in outline, occasionally idiomorphic, and of variable size, measuring in extreme cases 2 inches long by $\frac{1}{4}$ of an inch wide. They contain biotite inclusions and are frequently twinned on the Carlsbad law.

Two sets of joints intersect the granite mass, which strike N. 70° E., and N.-S. The strike of the schistosity when observed approximated N. 45° E. The jointed surfaces are slickensided, thinly coated by a yellowish green mineral substance. The spring waters issue from and along the jointed surfaces in the granite, and they are reputed to have considerable medicinal value.

Microscopical Examination.—Under the microscope a thin section of the rock showed a fine-textured biotite granite-gneiss in which the gneissic structure is pronounced, and extensive shattering or crushing and recrystallization of the mineral grains indicated. The essential composition of the rock is potash and plagioclase feldspars largely, orthoclase with scant microcline, quartz, and biotite. The biotite shreds are arranged

along parallel lines, and they are intergrown with some shreds of muscovite. Occasional areas of micrographic intergrowths of quartz and feldspar are noted.

THE MURDOCH PLACE.

About 4 miles slightly east of south from Statesville and 1½ miles east of Barium Springs, a fine-textured, massive, medium-gray muscovite-bearing biotite-granite has been slightly opened. The rock is exposed in the valley of a small stream and was worked some 10 to 12 years ago to obtain stone for local use. The opening is a very small one and only a few stone were quarried. So far as could be judged from the opening, the rock contains no injurious minerals; is entirely free from veins and other intersecting materials; and is a rather desirable granite.

Microscopical Examination.—Microscopically, a thin section of the rock revealed a fine textured biotite granite, composed of potash and plagioclase feldspars, quartz, and biotite. The feldspars and biotite are both largely altered yielding much colorless mica, epidote, and chlorite. Microcline is very subordinate in amount, but plagioclase is present in considerable quantity. Simultaneous crystallization of a part of the feldspar with the quartz is indicated in the micrographic structures as small areas distributed through the section. The effects of pressure-metamorphism are very pronounced in the minerals of the section.

THE WILHELM PLACE.

About 5½ miles southwest of Statesville (7 miles by the road) and about 2 miles from Catawba River on Doctor Wilhelm's place, an outcrop of granitic gneiss was worked for bridge piers some years ago. The opening is a small one and is made in an exposure of the gneiss just above a large spring, ½ mile off the Shoal's road.

The rock is a dark gray biotite granite gneiss, thinly schistose, and of medium texture. It is rather uniformly banded and, apparently would prove to be a desirable stone for street purposes.

Between the Wilhelm opening and Statesville the country-rock is mica-schist intersected in places by veins of crystalline quartz varying from several feet to 100 feet in width. Similar conditions obtain between Statesville and Barium Springs.

THE MILLS PLACE.

One and a half miles north of Statesville, on W. R. Mills' place, a small quantity of stone has been obtained for macadam purposes from an ex-

posure of gneiss. The rock is exposed along a small stream at the foot of a moderate hill slope. It is a very dark, coarse-textured porphyritic biotite gneiss, containing a large proportion of biotite. The feldspar phenocrysts are not abundant, but are large in size and of irregular outline, transparent and with good cleavage development. The fresh rock is covered quite deeply by deep red to chocolate colored residual clay. The stone is only suited for the rougher grades of work.

All along the public highway in this locality the rock decay is quite deep, varying from a dark red to chocolate brown, intermingled with considerable limonitic clays exposed in places, and the whole derived largely from a thinly schistose hornblendic rock.

Basic Igneous Intrusive Rocks.

The only dike of diabase observed in Iredell County is that mentioned under the McNeely quarry, one mile N. 70° W. of Mooresville. It is less than 6 feet across, striking N. 45° W., and penetrates the porphyritic granite.

In a general easterly direction from Statesville along the Statesville-Elmwood road, the rock between Statesville and Elmwood is identified as mica-schist from the residual decay. No fresh rock is exposed. About a quarter of a mile west of Elmwood along the same road, the schist is cut by a dioritic mass. The decay of the 2 rocks, schist and diorite, is strongly contrasted. The diorite is exposed over a large area in the form of large and small boulders, as far as sectioned, a distance of 5 or more miles N. N. E., from Elmwood. The rock is also reported as outcropping several miles to the southwest of Elmwood, and again to the northeast along the Cool Springs road where specimens were collected.

The diorite is penetrated in a number of places by very light colored, fine-textured granite dikes, which range from 3 to 12 inches in width and strike in a general northwest direction. This area is about 5 miles west of Barber Junction, where large exposures of typical diorite occur, and the Elmwood rock probably represents the westward extension of the Barber area in Rowan County. Between the two places, Elmwood and Barber, some mica-schist covers the diorite from view.

CABARRUS COUNTY.

Large areas of granite are found over many parts of Cabarrus County, limited principally to the west half of the County. The granites proper are biotite-bearing and include both porphyritic and even-granular rocks. Massive and schistose phases occur and in texture they vary from medium

to fine-grained. Exposures are numerous mostly in the nature of large and small boulders, with frequent ledge and flat-surface outcrops.

Schists of chloritic, sericitic and argillaceous types, intersected by large quartz veins and dikes of basic igneous rocks, compose the rocks of the eastern part of the County. The strike of the schistosity is N. 20°-30° E., with dips N. 70°-80° W. Eruptive basic rocks in the form of dikes are common to both the granite and the schist areas of the County.

As yet very little quarrying has been done; 3 small openings will include the extent of quarrying in the county. The lack of developments in some of the larger and more important areas prevents positive statements of the commercial value of the granite.

ROCKY RIVER GRANITE AREA.

Entering the County from the southwest, at a point close to but south of the Southern Railway, northeast of Charlotte, a section made in a general northeast direction to Concord, the county-seat, traverses granite for nearly the entire distance.

THE TEEDERS PLACE.

Along the east side of the Southern Railway and less than a quarter of a mile west of the Rocky River road and approximately one mile southwest of Fore's mill on the river is an extensive area of granite. The rock is continuously exposed in large and small bouldery masses over not less than fifty acres of surface, in a general direction parallel to the railroad. Scattered small outcrops of the same rock are traced northward to the river at the mill, where the exposures again assume large dimensions and the rock is of decidedly coarser texture. The rock has not been opened but the exposures on the Teeders place show a firm and even-textured biotite granite of moderate dark gray color, and, in places, slightly schistose in structure. Measurements of the jointing in the exposures at the mill showed two sets of planes, striking N. 40° W., and N. 70° E. The area is readily accessible, and so far as could be judged from the surface exposures, the rock is of good quality. The coarse-textured rock crosses the river at the mill and is recognized by its decay for some distance along the road.

THE STEWART PLACE.

About 4 miles west of south from Concord on the Stewart Place and near the railroad crossing over Coddle Creek, a fine-textured dark gray biotite granite (?) outcrops in boulder form on both sides of the

Rocky River road. The rock somewhat resembles that described above on the Teeders place. No openings have been made. Hand specimens were collected from a small exposure on the road side within a few paces of the Stewart house.

Diorite is exposed along the road between Rocky River and Coddle Creek, 5 to 6 miles west of south from Concord. On the north side of and less than a quarter of a mile from Rocky River along the same road, a diabase dike penetrates the coarse-textured granite.

SOUTHWEST LIMITS OF CONCORD.

Near the southwest limits of the town of Concord and about $1\frac{1}{2}$ miles from the center of the town immediately on the west side of the Rocky River road, is a granite exposure, about 10 feet high and covering less than a quarter of an acre of surface. The rock is a uniformly fine-textured pink granite of desirable quality. Jointing is in 2 directions, spaced at close intervals, and limiting in size the blocks that would be possible to quarry. The strike of the joint-planes is N.-S., and E.-W. No other exposures of the granite were found, hence the extent of the rock could not be determined. Should the rock be found in quantity, and dimension stone be obtainable, the uniform color and texture make it a very desirable granite for use as monumental and decorative stone.

Microscopical Examination.—Under the microscope a thin section of this rock shows a very fine-textured biotite granite made up of a complex interlocking aggregate of potash feldspars and micropertthitic intergrowths, and quartz. Plagioclase as single individuals entirely fails. Very little biotite is distributed through the section and it is in small irregular flecks largely altered to the usual by-products. No injurious minerals occur in the rock.

Augite Syenite.

Beginning about 4 miles southwest of Concord, the Rocky River road traverses an extensive area of coarse-textured augite syenite which extends within $1\frac{1}{2}$ miles of the town of Concord. The area is approximately 3 miles wide, measured in a southwest direction. Outcrops of the rock are numerous on both sides of the road, in the nature of immense boulders which measure 10, 20 and 30 feet high and proportionately large otherwise (see Fig. B, Pl. IX). Similar exposures are reported to the south and east of Concord, which would apparently mark a northwest-southeast belt of this area. See p. 265 for tests as road metal.

The rock is of uniformly coarse texture over the entire area, of massive structure and composed of large bluish gray feldspar individuals, without pronounced crystal outline (allotriomorphic). It contains little of the other minerals, as a rule, but is largely made up of the coarse crystallization of feldspar. The large feldspar individuals are wrapped about each other and are closely interlocked, imparting a close texture to the rock as a whole. When closely examined, the feldspar shows a decided pinkish tone, but not of sufficient depth to be noticeable in the general color of the rock, which is a pronounced bluish gray.

The small amount of groundmass present in the rock is coarse-textured and dark gray from the proportion of the dark bisilicates present. It occupies small but distinct areas between the larger feldspar individuals.

Boulders of the partially decayed syenite are buried to some depth in a coarse-grained soil derived from the decay of the rock, which varies in color from yellowish red to very light rusty gray in color. Oxidation is only partially complete and the rock crumbles principally from the action of physical forces.

At several points along the Rocky River road boulders of the syenite have been split and a few stone quarried for local use. About 3 years ago the Balfour Quarry Company opened a quarry in a large bouldery ledge outcrop of the syenite immediately on the Rocky River road, 3 miles southwest of Concord on Mrs. Parrish's place. The rock was quarried for ballast. The opening is about 50 by 75 yards, and along the quarry-face it will average about 25 feet in depth. The stone is quarried by blasting and, in consequence, the rock is greatly shattered and torn (see Fig. A, Pl. X). Two sets of joints showing slickensided surfaces, cut the granite mass striking N. 40° W., and N. 40° E.

Microscopical Examination.—A thin section of the rock from the Balfour Quarry Company's opening, 3 miles southwest of Concord, showed microscopically, a coarse-textured, augite-hornblende-biotite syenite composed very largely of feldspar with slight quartz, and the accessories mentioned. The feldspars are orthoclase, microcline, microperthitic intergrowths, and subordinate plagioclase (oligoclase). These are usually rimmed by a wide zone, or border, of a very fine-grained mosaic of the feldspar as a result of extensive pressure-metamorphism. The feldspars are further filled with minute closely crowded hair-like inclusions of rutile and small particles and granules of magnetite and minor accessories. Green augite (diopside) is the principal ferromagnesian silicate. Hornblende of green color exceeds biotite in amount. Both the hornblende and the biotite show some alterations. Considerable magnetite, some kaolin and a few grains of pyrite, with minor micro-



A. BALFOUR QUARRY COMPANY'S QUARRY IN AUGITE-SVENITE, $3\frac{1}{2}$ MILES SOUTHWEST OF CONCORD, CABARRUS COUNTY.



B. GRANITE BOULDER OUTCROP, DUNNS MOUNTAIN, 4 MILES EAST OF SALISBURY, ROWAN COUNTY.



A. BALFOUR QUARRY COMPANY'S QUARRY IN AUGITE-SYENITE, $3\frac{1}{2}$ MILES SOUTHWEST OF CONCORD, CABARRUS COUNTY.



B. GRANITE BOULDER OUTCROP, DUNNS MOUNTAIN, 4 MILES EAST OF SALISBURY, ROWAN COUNTY.

colored areas of biotite segregations and occasional thin veins of feldspar are observed in the rock in places. Pyrite is sparingly developed in small scattered grains and crystals, but it has not been noted in sufficient amount in any exposures of the rock to seriously injure the stone.

As a rule, the rock yields a light gray siliceous decay, though deep red colors are often shown from increased oxidation of the iron-bearing constituent, indicating a more advanced stage in the chemical decay of the rock. In the usual lighter colored decay the feldspars are much kaolinized, chalky-white in appearance, and the rock crumbles to a coarse granitic sand, in which the original minerals of the fresh rock are fairly well preserved and can be readily identified.

GRANITE ON THE EAST SIDE OF CONCORD.

Along the Stokes ferry road, 7 miles east of Concord, near Adams Creek, a fine-textured, massive, light gray, biotite granite is exposed directly on the road side. The rock contains much pyrite disseminated through it as small crystals and grains. It is quite uniform in color and texture and it would prove to be a very desirable granite except for the amount of pyrite contained in it.

Microscopical Examination.—Under the microscope a thin section of the rock from this locality, shows a biotite granite composed of the potash feldspars and striated plagioclase, the latter probably in excess, quartz and biotite. The biotite displays the usual alteration. Many large pieces of pyrite and some grains of magnetite are distributed through the section. Extensive shattering from dynamic forces is indicated in the very fine-grained mosaics of the quartz and feldspar.

THE REID OR CITY QUARRY.

Near the northeast limits of the town of Concord, some stone has been quarried from an exposure of granite and used for macadam on the streets of Concord. The rock is exposed along a small stream, the opening in which is small, averaging about 35 by 50 yards with a quarry-face of 10 to 20 feet in depth. Jointing is at close intervals and makes it impossible to quarry dimension stone. The strike of the joint-planes is N. 60° W. Abundant segregation areas of the ferro-magnesian minerals are distributed through portions of the rock, ranging from one to several inches in diameter, and usually more or less rounded in outline. On account of the close jointing and the numerous areas of dark-colored segregations, the stone cannot be used in first grade work. Results of tests of this rock for road material are given on page 265.

The rock is a medium-textured, biotite-hornblende granite of gray color. It is penetrated by a single dike of a basic igneous rock, striking N. 30° E. The rock composing the dike is thinly schistose in structure, but the enclosing granite is entirely massive, though indicating considerable movement in the mass in the complete development of slickensided joint surfaces. Clearly the granite was subjected to precisely the same metamorphosing influences as the dike, and that it is massive and not schistose indicates conclusively its greater resistance to pressure-metamorphism than that of the dike.

Microscopical Examination.—Microscopically, the rock is a medium fine-textured, hornblende-biotite granite, composed of orthoclase, microcline and a large proportion of a striated plagioclase, quartz, with nearly an equal quantity of hornblende and biotite. Both the hornblende and the biotite are considerably altered into a number of the most usual alteration products derived from these minerals. Crystals and grains of magnetite are quite freely distributed through the section.

Granite Porphyry.

Six miles east of Concord a deep pink, very fine-grained granite is exposed immediately in the Mt. Pleasant road. The exposure in the road is less than 100 feet across. Careful search failed to indicate further trace of the rock on either side of the road in the fields, and the character of the decay or soil away from the road on the two sides affords no indication whatever of the rock. In view of these facts no estimate as to the probable extent of the rock was possible. It is possible that the rock forms a dike whose width approximates 100 feet with a general approximate strike north and south. This, however, is entirely conjectural and must be so accepted until other possible outcrops of the rock are found that will indicate the exact conditions. An 8 inch cube of the rock collected from this exposure is exhibited in the building stones collection in the State Museum at Raleigh. It is susceptible of a high polish and its properties in general prove it to be a very desirable stone should it be found in quantity.

Megascopically, the rock is a very fine-grained, deep pink or red feldspar-quartz aggregate, in which no ferro-magnesian mineral is apparent to the naked eye. The texture is even granular with no semblance of the porphyritic texture indicated.

Microscopical Examination.—Under the microscope a thin section of the rock from this locality indicates an intermediate texture between that of a normal granite and the matrix or groundmass of granite porphyry.

The composition of the fine-grained aggregate is microcline, orthoclase, a little plagioclase, much quartz with no ferro-magnesian mineral indicated, but a few shreds of muscovite occasionally occur. The texture is exceedingly fine-granular with, under the microscope, a decided tendency to the porphyritic texture developed, in which quartz is the principal mineral showing this tendency. The quartz grains in many cases are conspicuously larger in development than those of the feldspar. They are entirely irregular in outline with no tendency toward idiomorphism indicated. The decided pink or red color of the rock is due to the distribution of bright cherry red particles of iron oxide as inclusions in the feldspars, and further distributed along the sutures of the interlocking minerals and the microscopic fractures in the individual mineral grains, when such occur.

SECTION ALONG THE ROAD FROM NEAR MT. PLEASANT TO CONCORD.

Outcrops of the fresh rock were not exposed at any point along the Mt. Pleasant road, but excellent sections of the rock decay are numerous. So far as it was possible to identify the decay, the original rocks yielding it were of two principal types, diorite and granite. A careful study was made of the best exposures of the decay all along the road with the hope of making out the possible relations between the two rocks.

The rock of dioritic composition is schistose in structure, much crushed and jointed. It is intersected by numerous quartz veins of variable width, from 1 to 12 and more inches across and by dikes of granitic composition of variable size. The decay is free from any decided red or yellow color which usually results from the oxidation of the iron-bearing mineral or minerals.

In places the granite is fresh enough to indicate an original pinkish tint. The more decayed portions of the rock show a rusty-yellow to brown color, in which the original minerals of the unaltered rock are in a partially fresh state of preservation. Schistose structure was nowhere evident, but the decay indicated a completely massive granite of medium-coarse texture, penetrated by very many dikes of a dark greenish-colored basic material, more or less completely decayed. These dikes vary from one to several feet in width and the contacts made by them with the enclosing granite are entirely sharp and well defined.

So far as it was possible to determine from the character of the decay derived from the 2 rocks, they do not appear to grade into each other, and they cannot be regarded therefore as facies of a single type. On the other hand, the facts as observed suggest that they represent separate

periods of intrusion. If they were both equally resistant to the dynamic forces, the diorite, since it is schistose and otherwise displays effects of pressure-metamorphism, must be regarded as relatively older than the massive granite. The somewhat close similarity of the granite dikes in composition to that of the main mass, found penetrating the diorite, apparently strengthens the belief that the diorite is older than the granite.

A second section along the China Grove-Concord road in a general northerly direction from Concord denotes closely similar conditions to that just described along the road extending east from Concord to near Mt. Pleasant. About 4 miles and beyond east of north from Concord the decay has the appearance of that derived from mica-schist. From this point to within $1\frac{1}{2}$ miles north of Concord the road traverses a belt of diorite, which is penetrated by numerous pink granite dikes. About $1\frac{1}{2}$ miles north slightly east from Concord the diorite is in contact with a medium coarse-textured granite. Here as in the other section the contact between the 2 rocks is sharp and indicates no transitional zone or passage of one rock into the other.

Within the town of Concord sections showing the diorite-granite complex are exposed along several of the streets. Similar conditions obtain at a number of places in the cuts along the Southern Railway to the north of Concord, and extending through several counties.

Basic Igneous Rocks.

Besides the areas of diorite described above to the east, north and southwest of Concord, dikes of basic rocks are frequent over the County, penetrating alike both granites and schist. Variation is from typical massive diabase to more or less schistose and altered hornblende types. These are in all respects the analogue of the basic dikes described in Mecklenburg and the adjoining counties. The more important ones are here noted.

Near Rocky River on the north side, a diabase dike cuts the coarse-textured granite exposed along the Concord road. Along the same road, boulder outcrops of dioritic rocks are noted at several points between the above dike of diabase and Concord.

On the Mt. Pleasant road, $5\frac{1}{2}$ miles east of Concord, a diabase dike 100 feet wide and trending approximately northwest, intersects the schistose diorite near the granite contact. Near the eastern limits of Concord, and beyond on the same road, numerous dikes of basic composition are found penetrating the diorite-granite complex.

Nitze² refers to diabase dikes penetrating the schists of the Gold Hill belt, which extends into the northeast part of Cabarrus County (p. 86),² and again 7 miles south of Concord (p. 121).² Also 12½ miles south of Concord on Caldwell creek, diabase and gabbro are mentioned in their relations to the granite (p. 125).²

ROWAN COUNTY.

One of the principal and most important granite areas in the State occurs near Salisbury in Rowan County. The area marks a nearly continuous ridge beginning about 4 miles east of Salisbury and extending southwestward for a distance of more than 12 miles. Numerous quarries have been worked over nearly all parts of the ridge and the stone has been widely used in North Carolina and the adjoining States for various purposes, principally as a general building and street rock. The first quarries were opened many years prior to the Civil War and quarrying has been continued at intervals to the present time. Both a light gray, nearly white, and a pink granite of uniform color and texture of most desirable quality are quarried on the ridge.

A second area of even-granular biotite granite is developed in the vicinity of Woodleaf, a station on the Charlotte-Winston branch of the Southern Railway, about 11 miles northwest of Salisbury. A number of very small openings are made in places over the area and a small quantity of the granite has been quarried for local use. Between Salisbury and Woodleaf, beginning 2 miles northwest of and continuing for a distance of 8 miles from Salisbury, on the Wilkesboro road, is a very large and continuous area of medium textured biotite, porphyritic granite. Exposures of the fresh rock are very rare, but the area is readily traced by the residual decay of the granite.

In addition to the granites, basic igneous rocks are quite widely distributed over the County, comprising the principal types, diorite, diabase, and gabbro. The latter rock, gabbro, is quarried at one point in the County for monumental stock, for which purpose it seems admirably suited. The other types of basic rocks might be used to advantage in certain grades of commercial work.

The various areas of granitic and basic rocks are readily accessible to the lines of railway which traverse the County, rendering transportation facilities very favorable to the quarry industry in the different granite areas. The individual areas are described below.

² Bulletin No. 3, N. C. Geol. Survey, 1896, pp. 86, 121, 125.

THE DUNNS MOUNTAIN GRANITE AREA.

Dunns Mountain, located 4 miles east of Salisbury, the county seat of Rowan County, forms a part of a conspicuous granite ridge some 12 to 14 miles in length, trending in a general northeast-southwest direction. The ridge character is more or less apparent throughout its course, but it becomes less well defined toward the southwest and in many places it can only be recognized from the rock exposures, which are not arched appreciably above the general level of the surrounding plain, but are more or less co-extensive with it. Dunns Mountain is the name given to the northern part of the ridge which is the highest point, its elevation being about 900 feet above sea-level and about 150 feet above Salisbury. Similar but less elevated portions of the ridge are locally known as Phillips Mountain, 6 miles nearly south of Salisbury, and Powlers Mountain, which forms a part of the extreme southwest extension of the ridge, about 9 miles southwest of Salisbury. The area is further located between the middle and southeastern portions of the County.

Over many parts of the ridge, especially Dunns Mountain proper and Phillips Mountain, the granite is exposed above the surface in the form of huge boulders 10 to 30 feet high and proportionately large in the other dimensions (see Fig. B, Pl. X, and Fig. A, Pl. XI). At other points, as on the steeper slopes and near the top, the loose residual decay has been stripped from the surface exposing large and continuous areas of the hard and bare rock surface (see Fig. B, Pl. XI). At still other places where the ridge character is less pronounced, large and continuous flat-surface areas of the hard and nearly fresh rock are exposed similar to that of the steeper slopes. Over the intervening areas nearly fresh granite outcrops in smaller areas but the rock is mostly overlaid by a variable depth of residual decay, including soil, from one to 10 feet, which on account of the slope can be easily stripped, in most cases, when desired. In many places over the ridge the exposures of the granite are sufficiently large to yield immense quantities of the stone without stripping.

The granite ridge roughly parallels the main line of the Southern Railway on the west, and at no point is it distant therefrom more than 4 or 5 miles. The Yadkin Railroad, a branch of the Southern, extending between Salisbury and Norwood in Stanly County, crosses the ridge just south of Dunns Mountain proper at Granite Quarry station, making it practicable to build switches and open quarries over almost any part of the ridge.

As regards color, two distinct and important grades of the granite occur which are quarried over parts of the ridge, namely, a very light

gray, nearly white; and a decided pink or flesh colored stone. As shown below, this differentiation is based entirely on color since both the pink and the gray granite have identically the same texture and mineral composition and are closely similar in other less important particulars. Again, this difference applies in color only to the northeast half of the ridge, a distance of some 5 or more miles. From Phillips Mountain, near the village of Faith, southwestward, the granite of the ridge is all decidedly of the very light gray nearly white color, with none of the pink shade indicated.

Since the color and texture as well as the other properties of the pink granite make it a most desirable stone for certain grades of work, inquiry into the quantity of this grade of the granite is of prime importance. Field study early developed the fact that the possible relations existing between the pink and the gray granite bore directly on the problem and accordingly three possibilities were suggested: First, that the pink color is a superficial phenomenon; second, that the pink and gray granites represent different intrusions; and lastly, that the 2 colors are phases of the same rock-mass.

In both the pink and the gray granite the color is imparted by the feldspathic constituent, since the subordinate amount of the ferromagnesian mineral, biotite, present in the rock, exercises practically no control over the color. That the pink color is not a superficial phenomenon is shown first by the fact that in those openings from which the pink granite has been quarried the color is uniform for the entire depth of working. Secondly, that over those portions of the ridge where the pink and the gray granite occur, having microscopically the same texture and mineral composition, and otherwise the same megascopically, no valid reason offers why, if the pink granite were a superficial phenomenon, it does not extend to all parts of the surface rock, rather than to certain areas, since similar conditions obtain for all portions of the ridge superficially, where the pink and gray rock are associated. It is true, however, that over all parts of Dunns Mountain proper, the granite shows more or less of a pronounced pinkish tone, grading further south into the light gray colored rock without appreciable trace of the pinkish tone evident. The pink granite extends at intervals as far south as the village of Faith where several openings have been made in it; but beyond this point southwestward the granite is entirely of the light gray color. Between Dunns Mountain proper and the village of Faith most of the rock is light gray, although several quarries have been worked within these limits in the pink granite (see Pl. XVI, A and B).



A. BOULDER QUARRY ON PHILLIPS MOUNTAIN, 1 MILE SOUTHWEST OF FAITH, ROWAN COUNTY.



B. BARE SURFACE EXPOSURE OF GRANITE ON THE NORTHEAST SLOPE OF DUNNS MOUNTAIN,
ROWAN COUNTY.

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B. BARE SURFACE EXPOSURE OF GRANITE ON THE NORTHEAST SLOPE OF DUNNS MOUNTAIN,
ROWAN COUNTY.

The entire field evidence is against the possibility that the pink and the gray rock represent separate intrusions. Not a single fact from careful field study favors such an hypothesis, but on the contrary the field evidence is conclusively against such. Neither does there seem to be any evidence favoring the possibility of a process of segregation from the cooling magma, whereby the one colored rock was differentiated from the other, such as has been observed at times in some granite masses.

The possibility which seems to be the most plausible and the one to which the facts more nearly conform is that the pink and the gray granite are phases of the same rock. Where observed by the writer, the transition at every point from one color to the other is a more or less gradual one, and marked at no point by an abrupt or sudden change in color. Not only is there a gradual blending of colors in the two but no difference in structure, texture and mineral composition is developed from microscopic study, but the two differently colored rocks are identical in all respects save that of color. The feldspar content, which controls or conditions the color of the rock, indicates practically no appreciable difference between the pink and the gray granite, so far as revealed by the microscope; but the same species in nearly the same proportions are shown in all the thin sections examined of the differently colored rock. Why the feldspar contained in the granite at one point should be entirely pink; and nearby, through a gradual change is nearly white without trace of the pinkish tint indicated, has not yet been definitely determined for this area.

On the basis that the two colors represent phases of the same rock, no rule can be laid down for determining how much of either colored rock may be looked for in the granite boss, for variation in color may be expected to take place either vertically or laterally, or in both directions. In this particular area the rock actually exposed to view over the ridge indicates considerably a preponderance of the light gray granite including much of the mixed pink and gray colored stone over that of the pronounced pink color. While the quantity of the pink granite is much less than that of the gray, shown by surface exposures and openings, conditions point to a very large supply of the pink granite.

The light gray granite is equally strong and durable as the pink granite, but much less desirable for a high grade of building or monumental work.

The granite has been extensively quarried in many places over the ridge, and it has had a wide usage in nearly all grades of work in which granite is used, both in and out of the State. Large quantities of it have

been and are still being quarried and worked into flagging and curbing for street purposes. Quarrying on the ridge dates back many years prior to the Civil War, and the large number of openings made over many of its parts may be grouped as follows, beginning at the extreme northeast end of Dunns Mountain and extending southwestward therefrom:

- I. Quarries on the north slope of Dunns Mountain.
- II. The Dunns Mountain (McCanless) quarries.
- III. The Rowan Granite Company's quarries.
- IV. The Balfour Quarry Company's quarries.
- V. The Consolidated Granite Company's quarries.
- VI. The Phillips Mountain quarries.
- VII. The Powlers Mountain quarries.

Numerous minor openings not included in the above list have been made in many places over the ridge, but practically none of the stone has been quarried from any of them, hence they are not considered under the list of quarries. The detailed characters and the desirability of the stone over the ridge are best brought out in the description of the individual quarries treated below.

QUARRIES ON THE NORTH SLOPE OF DUNNS MOUNTAIN.

About 4 miles east of Salisbury a number of openings have been made on both sides of the Stokes Ferry road in the granite on the north slope of Dunns Mountain proper. These include several openings grouped closely together directly on the north side of the road made in boulder outcrops on the Crawford place; and the openings made in the steep northeast slope of Dunns Mountain proper, on the south side of the road, and separated from the Crawford openings by a distance of about 400 yards.

Two openings on the Crawford place from which some stone has been quarried are made in huge boulder outcrops of a pronounced pinkish-gray granite. The boulders attain a height of from 10 to 30 feet and are proportionately large in other directions. Variation in color of the fresh granite is from decidedly pink to light gray, nearly white, with more or less mixed pink feldspar present in all of the stone. As a rule, the sap or partially decayed and discolored granite is very thin on the boulders. The feldspars of the partially decayed rock are white and opaque without luster, from kaolinization, and slight iron staining occurs from the partial leaching and alteration of the biotite.

Two sets of joints cut the rock at rather wide intervals, which strike approximately N. 50° E., and N. 25° W. Large dimension stone can be



A. DUNNS MOUNTAIN GRANITE COMPANY'S QUARRY, EXPOSING FRESH AND DECAYED GRANITE.



B. QUARRY NO. 2 OF THE ROWAN GRANITE COMPANY, $4\frac{1}{2}$ MILES SOUTHEAST OF SALISBURY.

readily quarried. Veins, dikes and segregations do not occur in the rock, nor are any injurious minerals indicated. The rock is of uniform medium texture, containing a very subordinate amount of the dark silicate biotite, which almost entirely fails in some places. The granite in these openings exhibits good working qualities and it is a desirable stone for most uses made of granite. The microscopic characters of this rock are brought out in the description given below of the granite on the north slope of Dunns Mountain proper, 400 yards further south, which is identically the same rock.

The north slope of Dunns Mountain proper exposes a bare, steep ledge of the granite more than 100 feet long and wide, which has been prospected along the foot and the middle portions of the slope (see Fig. B, Pl. XI). As indicated in the openings, the sap or partially discolored surface rock rarely exceeds a foot in thickness and the fresh granite is quite uniform in both color and texture. The summit of the mountain rises considerably over 100 feet above the level of the surrounding plain, with large areas of bare ledge and huge boulder exposures of the granite over the north, east and south slopes of the mountain. Some of the largest boulders are more than 30 feet high and proportionately large otherwise (see Fig. B, Pl. X). On top of the mountain, similar exposures of the granite are seen. Over most of the mountain, including the summit and slopes, the granite is covered by a sufficient depth of loose residual decay to support a moderately thick growth of trees and smaller plants. The Yadkin Railroad, a branch of the Southern, crosses the ridge about one mile south of this point.

Over the summit and north slope of the mountain pronounced shear zones of crushed and laminated rock of very narrow width, not exceeding 2 feet, and spaced at wide intervals, are developed in the granite. These zones follow or are coincident with the direction of the jointing which strikes N. 60°-70° E. Strike of the shear zones on top of the mountain at the picnic grounds is N. 55° E. The surfaces are usually slickensided and coated with a thin veneer of a yellowish green mineral substance, which is in part epidote.

The rock is a pronounced flesh-colored pink granite of a mixed pink and gray tint, and of medium texture. Here, as over all parts of the ridge, the rock in the exposures shows a moderately developed schistose structure resulting from pressure-metamorphism. It is a beautiful granite capable of a high polish and possesses good working qualities. Small grains and crystals of magnetite are distributed through the rock in places, and sometimes pyrite; more or less epidote is developed at times as a secondary product from partial alteration. The granite is a very

desirable one for general building and other purposes, and dimension stone of any desirable size can be easily quarried.

Microscopical Examination.—Under the microscope thin sections of the rock show an aggregate of feldspar and quartz with no dark bisilicate as an accessory. Finely striated acid plagioclase may equal or exceed in quantity the potash feldspars. Microcline is present only in subordinate amount. Crushing and recrystallization from intense dynamic forces are pronounced in the thin sections, indicated in finer mosaics of the quartz and feldspar bordering the larger individuals and filling the interstices. The laths of plagioclase are fractured and broken and, in some instances, bent, with irregular fractures and strained shadows common to the other constituents. Carlsbad twinning is common among some of the feldspars. Scattered grains of magnetite and an occasional garnet are noted through the sections.

A small opening is made near the foot of the west slope of the mountain, about 300 yards southwest of the north slope, from which a very small amount of the stone has been quarried. The granite is identical with that described above both megascopically and microscopically. Small grains of magnetite are distributed through the rock.

A chemical analysis of this rock, as given by Lewis²⁰ shows the stone to be unexpectedly high in silica. The specimen analyzed was obtained from an opening at the foot of the steep bare slope on the north side of the mountain, and possibly does not represent the general average:

Analysis of pink granite, Dunns Mountain.

SiO ₂	75.14
Al ₂ O ₃	16.10
Fe ₂ O ₃	
MnO	Trace
MgO	0.04
CaO	0.93
Na ₂ O	5.82
K ₂ O	2.57
Loss on ignition	None
Total	100.60

THE DUNNS MOUNTAIN (MCCANLESS) GRANITE QUARRIES.

This property includes 452 acres, located $4\frac{1}{2}$ miles southeast of Salisbury and less than a half mile north of Granite Quarry station on the

²⁰ Lewis, J. V., Notes on Building and Ornamental Stone, First Biennial Report, N. C. Geol. Survey, 1891-1892 (1893), p. 89.



ROWAN GRANITE COMPANY'S QUARRY, NEAR THE YADKIN RAILROAD, $4\frac{1}{2}$ MILES SOUTHEAST OF SALISBURY.

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ROWAN GRANITE COMPANY'S QUARRY, NEAR THE YADKIN RAILROAD, $4\frac{1}{2}$ MILES SOUTHEAST OF SALISBURY.

Yadkin Railroad. It extends from the base of Dunns Mountain proper to within 400 yards of the above named station on the railroad. A total of about 45 openings, large and small, are reported made over this property, most of which are in the nature of prospect openings and from which little or no stone has been quarried.

The principal quarrying on this property has been confined to three large openings, which were being worked during the summer of 1903. The average dimensions of the largest openings are 267 feet long by 100 feet wide and 30 feet deep. The sap or partially decayed granite exposed in this opening will average 12 to 14 feet thick, as shown in A of Pl. XII. The largest dimension stone shipped from these quarries averaged 14 feet long by 6 feet wide by 3 feet thick. One hundred pieces, each 6 by 8 by 2 feet in size are reported to have been shipped to Reading, Pennsylvania. Results of tests of this rock for road material are given on page 266.

A spur track is operated between the quarries and Granite Quarry station on the Yadkin railroad. The equipment includes steam hoister and traveling cranes, derricks and drills, all of steam patterns. A number 3 rock crusher, having a capacity of 300 yards of stone per day, is equipped and operated at the quarries for utilizing the quarry waste for road macadam and ballast. The principal use made of the stone has been in buildings and in the shape of blocks and curbing for street purposes, and as macadam and ballast. It has been shipped for use to various points in the Carolinas, Virginia and Georgia, Reading, Penna., and Washington, D. C.

Two principal sets of joints intersect the granite in the large openings, striking N. 30°-40° W., and N. 15°-20° E. Both sets of the planes are slickensided, and they are spaced at sufficiently wide intervals to admit stone of almost any size blocks being quarried. What appears to be a segregation-shear zone of about 150 feet in width is observed in one of the openings, composed of dark gray augen-gneiss alternating with bands of nearly white granite two or more feet thick, having as nearly as could be determined a north-south trend. No injurious minerals nor blemishes were observed in any of the rock of the McCanless openings.

The rock is a uniformly light gray granite of medium texture and of excellent working qualities. The feldspars assume a pinkish tone in places, which imparts more or less of a pinkish gray color to the rock, but the pink color is not intense enough nor sufficiently extensive, so far as prospecting on this property indicates, to warrant the quarrying of a separate grade of pink granite. The color and texture of the rock are quite uniform and the stone is a very desirable one for most pur-

poses for which granite is used, especially as a general building stone. The rock is hard, firm and lively in appearance and it works well under the hammer. It takes a good polish and is susceptible of fine carved work, as displayed in some specimens of the carved stone at the quarries ready for shipment in July, 1903.

THE ROWAN GRANITE COMPANY'S QUARRIES.

The quarries of the Rowan Granite Company are located within a few hundred yards of Granite Quarry station on the Yadkin Railroad and about $4\frac{1}{2}$ miles southeast of Salisbury. Some 12 to 15 openings are made in different places over the 300-acre tract owned by this company. The two largest openings are within 200 yards of each other in a N. 30° E. alignment, and in size will average about 200 feet long by 150 feet wide and worked to an average depth of 32 feet. Pl. XII, Fig. B, and Pl. XIII, are views of these quarries. Dimension stones weighing 70 to 100 tons each were being quarried from the southwest opening, quarry number 2, in the summer of 1903, to be used in the construction of a dam across the Yadkin River (see Pl. XIV).

Jointing in a number of directions breaks the stone into polygonal blocks of many different sizes, but while the planes intersect the rock at varying intervals, they are usually spaced far enough to permit blocks of almost any dimensions being quarried. Variation of a few degrees is indicated in the jointing in the different openings. Measurements made of the jointing in the principal openings on this property gave the following results:

N. 80° E.	N. 25° E.	N. 70° W.
N. 65° E.	N. 20° E.	N. 50° W.
N. 45° E.	N. 15° E.	N. 45° W.
N. 40° E.	N. 10° E.	N. 40° W.
N. 35° E.		

In the two largest openings the jointing indicated the following directions in the strike:

Quarry No. 1.	N. 40° E., and N. 40° W.
Quarry No. 2.	N. 35° - 45° E., and N. 45° - 50° W.

The stone quarried by this company is a light gray granite, more or less speckled in places with a pinkish feldspar, not sufficiently pink in color nor uniformly distributed through the rock to influence appreciably or modify the light gray color, except at very close range and by close



ROWAN GRANITE COMPANY'S QUARRY, SHOWING THICKNESS OF GRANITE SHEETS THAT ARE CLEAVED
AND QUARRIED.

scrutiny. The stone possesses good working qualities and dresses well under the hammer, and it is well suited for the various uses made of it.

The granite has been used as a general building stone, for street purposes in the form of curbing and blocks and to a slight extent in monumental stock. Also a large quantity of ballast is reported to have been crushed and shipped from the quarries. It has been shipped for use to Washington, D. C., and to the most important points in Virginia and North Carolina, and to a limited extent to a few other States.

The equipment at these quarries is very extensive and is entirely modern, which admits of the ready and easy handling of the stone. A No. 6 Gates rock crusher is installed and operated at the quarries for utilizing the quarry-waste in the form of ballast and macadam for road and street purposes. Preparations for more extensive quarrying and the enlarging of the equipment were being rapidly made in July, 1903. The installation of an adequate engine and dynamo for operating a 20-ton overhead electric traveler was then under way. At that date the power plant was expected to be completed within 3 months.

In the 2 large openings, quarries Nos. 1 and 2, the granite shows in places an advanced stage of decay, varying in depth from the surface downward, from 5 to 6 feet and occasionally more. In quarry No. 1 the granite at one point is completely decayed to a depth of more than 10 feet (see Fig. A, Pl. XVII). The weathered product consists of light red and gray granitic sand and clay, that can be easily removed with the pick and shovel. As indicated in the figure, the weathering of the granite at this point is after the manner of the typical concentric form, into layers of mixed red and light gray colors. The entire mass is reduced to a soft siliceous clayey material, in which the layered or shelly structure is completely preserved.

In quarry No. 2, oxidation seems not to have progressed quite so far in the process of weathering, and the decayed product on the northwest side is a light gray colored mass of partially hard and soft decay, in which the individual minerals of the fresh granite are easily distinguished. This depth of decay is somewhat extreme and does not extend over all portions of the 2 quarries. As a rule, hard and firm nearly fresh granite, only slightly discolored to a depth of a few inches, characterizes the principal exposures of the granite on this property; though not infrequently white, lusterless, chalk-like granite showing more or less discoloration from the liberated iron oxide of the mica, and due largely to the advanced kaolinization of the feldspars, reaches depths of many feet. Boulders split by blasting are seen to be discolored from weathering frequently 5 or 6 feet from the surface (see Pl. XV).

THE BALFOUR QUARRY COMPANY'S QUARRIES.

The quarries of the Balfour Quarry Company are located within less than a half-mile south of the Rowan Granite Company's quarries, near Granite station on the Yadkin Railroad; about 5 miles N. 20° W. of Salisbury and 2 miles northeast of Faith. Two openings have been made near together, the smaller one of which is hardly more than a prospect and is made in light gray granite of the same color, texture and composition as that quarried by the Rowan Company described above.

The principal quarry or opening of this company is in a beautiful pink granite known as the Balfour pink granite quarry. The opening is made in a ledge exposure of the granite having a slope of about 25 degrees. Practically no soil—residual granite decay—covers the granite except on the east side, where slight stripping is necessary before quarrying. The sap or partially discolored rock is very thin over most of the exposure except on the southeast side of the opening where the partially discolored rock attains a thickness of several feet from the surface downward. On the north side of the opening entirely fresh rock begins practically at the surface. Some weathering from oxidation resulting in a reddish discoloration of the rock, amounting to hardly more than a thin veneer, is observed along the jointed surfaces (see Pl. XVI).

Two sets of vertical joints break the granite into large blocks striking N. 10° E., and N. 70° W., and are spaced at sufficient intervals to admit of quarrying dimension stone of almost any size. The jointed surfaces show slickensides. So far as quarrying operations have extended, in depth not exceeding 30 feet, the rock appears to be disposed in plates or sheets which vary in thickness from 2 to 10 feet, with a probable average of 8 feet. No veins nor dikes penetrate the rock in either of the openings, and the granite is entirely free from any injurious minerals.

The rock is a beautiful pink granite of uniform color and texture and should prove to be an excellent stone for all purposes that require the best grades of granite. Its susceptibility of a high polish makes it a most desirable stone for monumental and decorative stock. The texture is medium-grained similar to that of the light gray granite. The ferromagnesian constituent, biotite, is very sparingly developed in the rock; and the feldspathic constituent, uniformly colored pink, is evenly distributed through the stone. The working qualities of the rock are excellent and dimension stone of any size is easily quarried.

Microscopical Examination.—A thin section of the fresh rock collected from the pink granite quarry showed under the microscope a complexly interlocking aggregate of feldspar and quartz. The effects of shattering



ROWAN GRANITE COMPANY'S QUARRY, $4\frac{1}{2}$ MILES SOUTHEAST OF SALISBURY, ROWAN COUNTY, SHOWING DECAYED GRANITE AND THE AMOUNT THAT IS STRIPPED.

and recrystallization by dynamic forces are strongly emphasized in the section. The larger feldspar individuals are all bordered by a fine-grained mosaic, while the quartz occupies distinct and well-defined areas between the feldspars as a very fine aggregate of interlocking grains in which similar grains of feldspar may or may not occur. The plagioclase laths are broken in some cases, and fractures and undulous extinction characterize the other minerals to a large degree.

The feldspathic constituent is composed of orthoclase and a nearly equal amount of stout, finely striated acid plagioclase, with only occasional grains of microcline. The feldspars are filled with closely crowded dust-like particles of a brownish red color. No dark bisilicate is indicated in the section examined. Occasional grains of titaniferous iron oxide are scattered through the section, more or less altered peripherally into a clear and colorless titaniferous by-product. Small, almost microscopic grains of pyrite occasionally occur, but seem to have no deleterious effect.

Efficient modern equipment, including the necessary tools for polishing, is being installed at the quarry for quarrying and handling dimension stone of any desirable size. Stone from this quarry was used in the building of the Catholic University in Washington, D. C. This grade of pink granite is in much demand in Chicago and other northern and central cities for use as monumental stock. This granite will be used in the construction of the new Municipal court building in Washington, D. C. During the summer of 1905 the grade of light, nearly white granite was being quarried chiefly for use in paving only, and was being shipped principally to Cincinnati, Ohio.

THE CONSOLIDATED GRANITE COMPANY'S QUARRIES.

The Consolidated Granite Company's property includes 151 acres located $5\frac{1}{2}$ miles south of Salisbury and bordering the northern and eastern limits of the village of Faith. It is distant $1\frac{3}{4}$ miles from the nearest railroad point. A survey of the route from Yadkin Railroad and the quarries has been made relative to building a spur track for hauling the stone. This company had only assumed control of the property a short time previous to July, 1903. Extensive preparations were then being made for installing all the necessary modern equipment for the quarrying and handling of dimension stone; the erection of crushers for the utilization of the quarry-waste; and the necessary machinery for the proper shaping of granite for the various uses made of it.

Prior to the Consolidated Company's assuming control of the property, considerable stone had been quarried from a large number of openings over the tract at intervals dating back some years prior to the Civil War. Numerous shipments of the stone were reported to have been made during the early period of quarrying to various points in Virginia and North Carolina. Large areas of the hard and moderately fresh granite are exposed over the tract, requiring little or no stripping for quarrying. The sap or partially decayed granite from weathering is usually thin on these exposures and is easily removed with the first raise. Where covered by the loose residual decay the covering is, as a rule, of slight depth and can be quite easily removed. Except in a few places, the slope of the ledges is sufficiently steep to afford almost any reasonable depth of quarry-face.

Two grades of granite have been quarried in different places on this tract; a light gray granite of the same texture and color as that quarried near Granite Quarry station by the Rowan Granite Company, and a pink granite of the same depth of color and texture as that quarried farther north on the ridge by the Balfour Quarry Company. Numerous openings have been made in both the pink and the gray stone, which affords some basis for judging of the extent of the two differently colored granites. So far as revealed in the openings, the pink granite is in large quantity on this tract, and is quite uniform in both color and texture to the entire depth of the openings in which it is exposed. The gray granite in which a sprinkling of pink feldspars occur in many places makes up the bulk of the granite exposed over the tract. The two colors, pink and gray, are observed grading more or less gradually into each other, in a number of places on the property.

Vertical jointing is quite strongly developed in several directions in the various openings, with the planes usually spaced at intervals sufficient to allow the quarrying of dimension stone of any desirable size. Measurements of the joint-planes in the numerous openings over the tract gave the following results:

N. 80° E.	N. 50° W.	N.-S.	E.-W.
N. 40° E.	N. 40° W.	N.-S.	
N. 10° E.	N. 30° W.		

The directions of the principal jointing are those which lie in the northeast and northwest quadrants. No veins, dikes, nor segregation areas were observed in the granite at any point; nor were there any injurious minerals contained in the stone likely to cause discoloration on exposure, so far as the field examination disclosed.

Megascopically, the rock is in all respects similar to that quarried by the Rowan Granite Company and the Balfour Quarry Company described above, near Granite Quarry Station on the Yadkin Railroad. The texture, color and working qualities are apparently the same as for the granite at the above locality, and it is equally as desirable a stone for all purposes.

Microscopical Examination.—Microscopically, thin sections cut from specimens of the pink and the gray granite collected on this property are essentially identical. Under the microscope the thin sections show an aggregate of interlocking feldspar and quartz in which lie occasional shreds of biotite. Orthoclase, with good cleavage development, is the predominant feldspar with plagioclase equal or nearly equal in amount, while microcline is only sparingly developed. Extensive mechanical deformation is indicated in the thin sections, of the same nature as described above for the Balfour Quarry. The feldspar individuals are frequently broken and the parts separated and cemented by veinlets or stringers of a quartz mosaic. This is especially true of the plagioclase and to a less extent of the orthoclase. Twinning on the Carlsbad law is noted and dust-like inclusions of reddish brown color crowd the feldspar individuals. Biotite is only sparingly distributed through the sections having the usual color and strong absorption and characterized usually by the same inclusions. Scattered grains of magnetite occur with a few minor accessories which exercise no effect on the rock.

In July, 1903, stone was being quarried to supply orders from San Francisco, Cal.; Jacksonville, Fla., and Indianapolis, Ind., for city work. Its uses for various purposes is reported to have been very extensive over the State.

THE PHILLIPS MOUNTAIN QUARRIES.

Phillips Mountain is the name given to a very large, low, conical peak, located about one mile southwest of the village of Faith, which marks the extension southwestward of the Dunns Mountain granite ridge. It is distant some 3 or more miles from the nearest railroad point. The granite is exposed over the surface of the peak in the form of huge boulder masses in which very many quarries have been worked and many of the boulders entirely or partially worked off. (See Fig. A, Pl. XI.)

The stone is a very light gray, nearly white biotite granite of medium texture and having excellent working qualities. The color and texture are quite uniform over the entire area and the granite is a very desirable one for nearly all grades of work. Blocks of almost any size can be

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readily quarried. The stone works well under the hammer and it is quite free from blemishes and injurious minerals of any kind.

A number of openings were being worked during the summer of 1903 and most of the stone quarried was being worked into curbing for street purposes. The rock is hard and tough, firm and compact, and lively in appearance and it should receive wide favor both as a general building and street stone.

The sap or partially discolored granite is usually thin on the boulders and, as a rule, occasions but slight waste in quarrying. In many instances, however, weathering has penetrated deeper from the surface, especially along some of the jointed surfaces, and is for the most part of the normal kind described above. A peculiar form of weathering of the granite which is rather common over many parts of the ridge and frequently met with in the exposures over Phillips Mountain, is described below.

Microscopical Examination.—Thin sections cut from specimens of the granite collected from the principal openings on the peak indicated under the microscope a medium textured mosaic of interlocking feldspar and quartz, through which is distributed very subordinate biotite. Plagioclase is nearly equal to or is quite as abundant as the potash feldspar. Orthoclase among the potash feldspars usually predominates, although microcline may be equal to it in amount in some sections. Feldspar intergrowths as micropertite are distributed through the sections. Dust-like inclusions occur in some of the feldspar and rarely Carlsbad twinning is developed. Biotite of the usual color and absorption is sparingly distributed through the sections and is either partially or entirely altered. Scattered grains of magnetite and a few other microscopic accessories are noted.

Effects of intense shattering and crushing of the feldspar and quartz grains from dynamic forces are conspicuously shown in the finer mosaics of these two minerals, and in the strain shadows and fractures in the larger individuals. The plagioclase individuals are frequently broken across the parts separated, and in some instances bent and curved.

Examination under the microscope of sections cut from some of the partially weathered and discolored granite indicates much iron oxide staining from the alteration and leaching of the biotite, while the feldspars indicate, as a rule, only moderate alteration.

THE POWLERS MOUNTAIN QUARRIES.

The low doming-mass of granite 3 miles southwest of the village of Faith and 9 miles southwest of Salisbury, locally known as Powlers Mountain, marks the southwest extension of the granite ridge in Rowan

County. The nearest railroad point is distant several miles from the area. The granite is exposed in more or less irregular hummocky surfaces, bare of loose residual decay over much of the area, but covered in places by a variable depth of the weathered product. Its greatest elevation is less than 100 feet above the surrounding plain and its slopes, while not entirely uniform, are somewhat gradual and admit of quarries being opened in ledges that would afford almost any desirable depth of quarry-face.

Several openings were made in places on the slopes of the doming-mass many years ago, when the surface raises were worked off. Examination of these ledges shows the rock to be considerably weathered, though still fairly hard and firm. The feldspars show a dead, lusterless appearance from kaolinization, and entirely fresh hand specimens of the rock could not be obtained. Two sets of joints which strike N. 20° E. and N. 70° W., break the granite into blocks of different sizes. The N. 70° W. set of joints is especially well developed and cuts the granite more frequently and at closer intervals than the former. As a rule, the intervals at which the joint-planes penetrate the rock are far enough apart to admit of blocks of almost any size being quarried.

The rock is a light gray granite very largely composed of feldspar and quartz, with very subordinate biotite. It contains no injurious minerals and is of medium texture. The size of the component grains in the rock is practically the same as that for the granite farther north on the ridge, but the mineral individuals do not appear to interlock in the same manner and the rock presents a somewhat different textural appearance. The difference may perhaps be less emphasized in the fresh rock.

About 300 yards east of Powlers Mountain proper an opening has been made in an extensive flat-surface exposure of a dark gray biotite granite of medium texture. Stone was quarried from the opening more than 30 years ago, when a moderate amount of stripping was done. The rock is entirely uniform in color and texture; contains a larger quantity of biotite than the average granite of the ridge and is therefore darker in color. It appears to be a desirable stone with fair working qualities, and is free from injurious minerals or blemishes of any kind. Dimension stone of any size can be readily quarried. While scarcely more than the surface raises were worked off from portions of the exposure, the rock appears hard and fresh and greatly more resistant to atmospheric agents than the rock in the ledges opened on the slopes of Powlers Mountain.

Microscopical Examination.—Microscopically, a thin section of the rock from this opening indicated an aggregate of feldspar and quartz,

which shows the same extreme effects of mechanical deformation as the thin sections of the granite farther north on the ridge. The finer mosaics of feldspar and quartz resulting from crushing are perhaps not so abundantly developed, but strain shadows and fractures are characteristic, and the broken parts of the feldspars are frequently bent and curved. The section shows some iron stained spots here and there resulting from the complete alteration and leaching of the biotite and probably some pyrite. Occasional grains of magnetite occur. Plagioclase nearly equals in quantity the orthoclase with microcline sparingly distributed.

THE JOSEY-BOGER PROPERTY.

Several miles S. 20°-30° W. of the village of Faith very large and continuous flat-surface exposures of a thinly schistose saccarhoidal granite-gneiss occur on the adjoining properties owned by Josey and Boger. As much as 25 acres and more of the exposed rock were observed in a single continuous outcrop, which was bare of any loose residual decay. Between the outcrops, the rock is mantled to some depth with the loose residual decay. A number of very small prospect openings have been made in several exposures of the granite at different places.

The rock is composed of a very white matrix of fine granular quartz and feldspar, speckled with small rounded areas of aggregates of black biotite, distributed at intervals and occupying distinct places, which impart a decided spotted appearance to the stone. It is a very thinly schistose rock and when broken in the direction of the schistosity the dark mica areas are of knife-edge thickness, a result of pressure-metamorphism.

The strike of the schistosity is N. 10° E., and the rock is penetrated by a well developed set of E.-W. joints spaced at intervals of from 4 to 12 and more feet. No veins, dikes, nor segregations were anywhere indicated in the rock, and it is free from harmful minerals. The granite-gneiss is in contact with an extensive belt of diorite on the east side. At this locality the rock is more completely schistose than that of any other part of the granite ridge, indicating more the effects of pressure-metamorphism. The study of thin sections of the rock from different parts of the ridge area is in full accord with the megascopic features as regards difference in the effects of extreme metamorphism.

Microscopical Examination.—Thin sections of the rock from the Josey-Boger places show microscopically a completely interlocking fine-grained aggregate of feldspar and quartz, in which crushing effects from dynamo-metamorphism are unusually strongly emphasized. The quartz is almost

completely crushed into a very fine mosaic, occupying somewhat distinct areas, while in addition to the crushing and granulation of the feldspar, much of it is broken, bent and curved, and strain shadows are intensified. Plagioclase exceeds in amount the potash feldspar, and orthoclase greatly predominates over microcline. Biotite is into distinct areas of aggregates of the usual color and absorption and shows partial alteration. Very occasional small grains of magnetite are distributed through some parts of the sections.

THE WOODLEAF GRANITE AREA.

In the northwest corner of Rowan County numerous outcrops of biotite granite occur in and around Woodleaf, a station on the Charlotte-Winston branch of the Southern Railway, about 11 miles northwest of Salisbury. Small openings have been made in the granite exposures in different places and some of the stone has been quarried for local use.

Near the northwest limits of the village of Woodleaf a small quantity of the stone has been quarried for local use from an opening made in a flat surface exposure of medium gray biotite granite of fine texture. The exposure is a small one and only a portion of the surface raise has been worked off. Very small segregated areas or blotches of biotite are distributed through the rock, which also has a slight schistose structure developed. Two sets of joints intersect the granite, striking N. 20° E., and N. 60° E. Abundant small pyrite crystals are developed along the surface of some of the joint planes, but as a whole the rock seems to be free from this mineral. The granite is only suitable for use in the ordinary grades of work.

Microscopical Examination.—Microscopically, a thin section of the rock reveals a very fine-textured biotite granite in which the principal minerals, feldspar and quartz, interlock in a very irregular and intricate fashion. The mineral grains are unequal in size, the larger ones displaying some effects of crushing peripherally, and the larger interstitial areas are filled with the finer mosaic of feldspar and quartz. Plagioclase as single individuals entirely fails, and the feldspathic constituent includes orthoclase and microcline, the former predominating, with abundant feldspar intergrowths in the form of microperthite. The feldspar is considerably altered, principally to muscovite. Biotite of the usual color and absorption is quite freely distributed through the section, though largely altered to a colorless mica, and there is a little chlorite, rutile and iron oxide. Muscovite as a secondary mineral, associated with the feldspar and biotite, is somewhat abundant. Micrographic areas of quartz and feldspar intergrowths are very common, and some epidote is noted.

About one mile west of the village of Woodleaf the railroad has cut through in a number of places a biotite granite of the same color and texture as that described above. A dark basic eruptive dike, approximately 300 feet wide and having a general northwest trend, penetrates the granite at this point. The same granite is again exposed in the shallow cuts along the railroad near the depot. In each of the cuts along the railroad exposing the granite, the rock manifests the effects of considerable weathering in the kaolinized, lusterless, feldspar and slight staining from the liberated iron oxide derived from the leaching of the biotite. The granite in the railroad cuts is further closely jointed, with several sets of planes breaking it into small blocks. The same granite but of porphyritic texture is exposed at the spring across the railroad from the depot.

One mile east of Woodleaf Station, directly on the east side of Third Creek and the south side of the railroad, a small opening has been made in a pronounced schistose granite-gneiss from which stone was quarried for bridge piers along the railroad. The rock is a fine-textured granite-gneiss of good quality and is a desirable stone for the ordinary grades of work.

Several other small openings are made in outcrops of the granite in the vicinity of Woodleaf. The granite is reported to be traced westward for a distance of 4 or more miles; and eastward 3 miles from Woodleaf along the Yadkin River at Cooleemee cotton mills, in Davie County, a similar granite is exposed from which stone was quarried for building the dam across the river at the cotton mills.

In the cuts along the railroad just east and west of the depot at Woodleaf, sharp contacts between the granite and the extensive belt of diorite, described below, are fairly well exposed, as indicated in B of Pl. V.

THE SALISBURY PORPHYRITIC GRANITE AREA.

Beginning about 2 miles northwest of Salisbury on the Wilkesboro road, is an extensive belt of coarse-textured, biotite, porphyritic granite, which can be continuously traced northwestward along the road by its residual decay, to a point about 8 miles from Salisbury. The porphyritic granite grades in many places along the road into an even-granular facies of the rock of the same texture and composition as the groundmass of the porphyritic rock. Only at one point were exposures of the fresh rock observed, namely, about 3 miles northwest of Salisbury immediately on the road, where a small opening had been made and a very limited quantity of the stone quarried for road macadam.

The groundmass of the rock is a medium-textured biotite granite of moderately dark color, containing much biotite. The phenocrysts are composed of potash feldspar, usually idiomorphic in outline and developing twinning on the Carlsbad law. As a rule, they are very large, varying from two or more inches long by a half to one inch wide. They contain inclusions of the groundmass biotite and in one or two places a tendency toward orientation was indicated.

The rock is deeply weathered, yielding a light gray granitic sand, rarely deeply colored from iron oxide staining. The large phenocrysts in a more or less kaolinized form are rather thickly strewn over the surface, and offer a very sure means of tracing the rock. These are sometimes split into smaller pieces along the cleavage directions, and in the shallow cuts along the road exposing sections of the decay. The partially weathered phenocrysts are observed distributed through the granite decay occupying exactly the same position in the decay as in the fresh rock.

BASIC IGNEOUS ROCKS.

Perhaps no county in the main granite belt of the State contains more extensive areas of igneous rocks of the basic types than Rowan. The principal types represented are diorite, diabase, and gabbro. Of these, diorite probably forms the most extensive areas. In one locality in the County gabbro is being quarried and used for monumental stock, and has already become favorably known in many of the towns over the State in this class of work. The extensive areas of some of the other basic types and the good qualities of the rock should bring them in favor for use in certain grades of economic work.

Diorite.

The rather extensive occurrence of this type of rock over some portions of the County renders it desirable to make some mention of it here. The most extensive area of diorite in Rowan County occurs in the northwest portion of the County. Beginning about 8 miles northwest of Salisbury along the Wilkesboro road, the easternmost extension of a very large area of the diorite is observed in contact with the porphyritic granite described above. The diorite is continuously traced from this point westward along the roads to Barber Junction and Woodleaf stations on the Charlotte-Winston branch of the Southern Railway; and northwestward into Davie County at the Cooleemee cotton mills. The area is traced farther westward into Iredell County where excellent exposures of the diorite are found in many places in the vicinity of Elmwood.

Very sharp and well defined contacts between the diorite and the granite are observed in the railroad cuts to the east and west of Woodleaf Station, and at no point studied by the writer do the 2 rocks grade into each other, but on the contrary the field evidence conclusively points to them as representing separate intrusions. The diorite shows marked variation in composition, color, and texture over the area. In color, variation is from a lighter colored rock in which plagioclase predominates over the hornblende, to a very dark colored rock composed largely of hornblende, with all gradations indicated between the 2 extremes. Naturally the variation in color is controlled or conditioned by the variation in composition already noted. The texture is medium-grained becoming coarser or finer in places as the case may be.

Microscopical Examination.—A large number of thin sections of the rock collected over all parts of the area show a typical diorite whose variation from place to place in the essential minerals, hornblende and plagioclase, is as stated above. Some of the sections show more or less quartz which in one or two instances is in amount sufficiently large to characterize the rock as a quartz diorite. The usual accessories are observed in the thin sections.

A second but smaller area of diorite of the same character and showing similar variations occurs on the Josey place, 3 miles S. 20° W. of the village of Faith, and about 8 miles nearly south of Salisbury, on the southeast side of the granite ridge in this vicinity, described above.

So far as the writer is aware no attempt has been made to quarry the diorite at any point in the County for any purpose, but it certainly forms a most desirable stone for road and street macadam, and it might be used to advantage in other classes of work.

Gabbro.

The only area of this rock noted in Rowan County occurs about 4 miles south of Barber Junction, along the Charlotte-Winston Railroad, in the extreme western portion of the County. At this point very large boulder cuterops are exposed over a considerable area, and the rock is quarried for monumental stock.

THE CONSOLIDATED GRANITE COMPANY'S (MCGALLIARD) QUARRY.

This quarry is located about 4 miles south of Barber Junction, within a short distance of the Charlotte-Winston branch of the Southern Railway, from which a siding is being built to the quarry. The rock was first opened about 4 years ago and has been continuously worked for

the past 8 months, dating from July, 1903. It is worked exclusively for monumental stock, and shipments of the stone for this purpose are reported to have been made to Chillicothe, O.; Baltimore, Md.; Washington, D. C.; Brooklyn, N. Y.; Danville, Va.; Charleston, S. C.; Shelbyville, Ind.; Raleigh and Wilmington, N. C. An order was recently placed for a \$5,000 monument to be erected from this stone in the cemetery at Winston-Salem.

The openings are small and entirely confined to the huge boulders which have not yet been worked off. The rock is practically free from sap or partially discolored stone from weathering, and no waste is occasioned from this source. Blocks of any desirable size are readily quarried. The stone for its kind works and dresses well under the hammer and takes a very high and excellent polish. The contrast between the hammer-dressed and the polished surfaces is very striking, a feature which taken in connection with its other excellent properties makes it a desirable stone for monumental stock. Occasional small grains and crystals of pyrite and knife-edge veinlets or stringers of dark greenish-colored mineral occur in the rock, but are not present in quantity sufficient to in any wise detract from the excellent qualities of the stone.

The rock is of medium texture, dark gray, almost black, in color and contains considerable biotite distributed through it. It compares quite favorably with the well known "black granite" of Addison Point, Maine. Being somewhat harder and tougher than granite, it is less easy and accordingly somewhat more expensive to quarry. This quarry is owned and operated by the Consolidated Granite Co. of Winston-Salem, N. C.

Microscopical Examination.—Microscopic study of thin sections of the rock shows it to be a norite containing much biotite, composed of orthorhombic and monoclinic pyroxenes largely hypersthene, plagioclase, a little orthoclase, some hornblende, a sprinkling of quartz, and titaniferous magnetite.

The texture is intermediate between typical ophitic and granitic with a stronger tendency toward the former or diabase texture (see Fig. B, Pl. II). The hypersthene is in massive, irregular, individuals without definite crystal outline, displaying the usual cleavage and strong pleochroism. The remaining pyroxene is non-pleochroic and of very pale greenish color by polarized light. The strongly pleochroic pyroxene shows very general alteration to the non-pleochroic variety of pale greenish tone, accompanied by the separation of iron oxide in the form of minute black grains. In this form of alteration the center of the individual is fresh hypersthene surrounded by an outer portion of nearly pale greenish form. In addition to this form of alteration there is a fair sprinkling of secondary hornblende possessing all the characters of

the primary compact form, for which there is no indication of a secondary origin. Still another form of alteration in the pyroxene is into a deep green fibrous mineral forming peripherally a fringe or border around the original mineral.

Much deep brown, strongly pleochroic plates of biotite are distributed through the thin sections and it is prominent in the hand specimens of the rock to the unaided eye. Abundant small grains and crystals of black iron oxide form inclusions in the pyroxene, biotite and feldspar. Plagioclase is abundant and is of the usual kind in such rocks, forming stout laths which, in many instances, display beautiful zonal structure.

Boulder outcrops of the same rock, but of finer texture, are traced over the surface on both sides of the railroad to within $2\frac{1}{2}$ miles south of Barber Junction. A number of thin sections of the rock collected from various places over the area were studied microscopically, indicating essentially the same composition but of finer and distinctly granitic texture. Thin sections of specimens of the rock collected $1\frac{1}{2}$ and $2\frac{1}{2}$ miles south of Barber Junction, respectively; and a half mile northwest of the quarry along the railroad, were characterized microscopically by an entire absence of biotite and only occasional secondary hornblende. The amount of magnetite is increased in all of the thin sections over that in the sections of the rock from the quarry.

Diabase.

Dikes of diabase are rather numerous over many parts of the County. Wherever they have been observed the rocks are very dark in color and usually fine textured, varying from olivine to olivine free diabase. Variation in the width of the dikes is from a few feet to 100 and more feet, and they strike in a general northeast and northwest direction. The dikes of this type of rock are especially numerous in the north and northwest portions of the County in the vicinity of the Cooleemee cotton mills. The more important dikes of diabase noted in the County are listed in the table of dikes on page 184.

DAVIDSON COUNTY.

The southeastern half of Davidson County forms a part of the so-called "Carolina Slate Belt." The rocks comprise chloritic and argillaceous schists with some altered, probably devitrified rhyolite, in which the flow structure is still apparent. Dikes of basic eruptive rocks of hornblendic composition intersect the schists in places. The strike of

the schists varies from N. 10° to 35° E., and in the dip the variation is from N. 40° W. to nearly vertical."²¹

Over the remaining portions of the County somewhat extensive areas of granite are found. Where examined, these belong without exception to the biotite type. They vary from massive to schistose in structure and from even-granular to porphyritic in texture, and are of gray color. The two textures represent different facies of the same granite-mass, as the porphyritic granite is found grading into that of even granular texture of the same mineral compositions. The porphyritic granite forms a very extensive area to the west of Lexington, the county-seat, and it is continuously traced westward across the Yadkin River into Davie County as far west as Advance Station, where it forms the country rock over the western part of Davidson and the contiguous eastern portion of Davie County.

The wide intervals at which outcrops of the massive and the schistose granites are found make it impossible to say whether the granites of schistose structure grade into the massive ones. Evidence from the decay of the two structural types is entirely lacking. The general appearance of the rocks in texture and mineral composition would indicate that the massive and schistose granites are structural phases of the same granite-mass for in the field the rocks are strikingly similar in all respects but structure.

To the south, north, and west of Lexington the country rock in places, is a variable schist ranging from biotitic and sericitic to quartzitic in composition. Sharp contacts between the partially decayed schists and granites were observed in several places, and the relations between the 2 rocks plainly indicate that the granites were of later date than the schists into which the former had been intruded. Dikes of basic composition penetrating these rocks are mentioned below.

The granites have nowhere been regularly worked in the County but some stone has been quarried from time to time from a number of places as needed to supply local demand. The openings are all small and are located in the vicinity of Lexington, the county-seat, where the rock has been principally used.

LEXINGTON GRANITE AREA.

THE CONRAD PLACE.

About 1½ miles north of Lexington on Joseph Conrad's place, several small openings, near together, have been made in outcrops

²¹ Nitze, H. B. C., Bulletin No. 3, N. C. Geol. Survey, 1896, pp. 60-74.

of a dark gray, fine-grained massive biotite granite. The openings were first made about 1856 and the rock quarried was used in the court-house building in Lexington, and bridge piers along the Southern Railway. The rock outcrops in the form of large boulders, flat-surface masses, and ledges over some 40 to 50 acres of surface.

The granite is quite uniform in texture and color and it contains no deleterious minerals. It should prove a desirable stone for general building and monumental purposes. The largest one of the openings does not exceed 50 feet square and is worked to a depth of probably 25 feet. Some of the blocks quarried in 1856 and left at the opening are as fresh to-day as when first taken out.

Microscopical Examination.—A thin section of the rock from the main opening on the Conrad place indicates microscopically a fine-grained biotite granite in which the mineral aggregates closely interlock. The feldspar consists of orthoclase and a little striated plagioclase, no microcline being observed. Twinning after the Carlsbad law is frequent and some alteration is shown in the feldspar. Biotite of the usual color and absorption is uniformly distributed through the section as shreds containing some inclusions and partly altered to chlorite, a colorless mica, and some epidote. Some rutile is associated with the biotite. Large stout prisms of apatite and small ones of zircon occur as inclusions. Small grains of magnetite are sparingly distributed through the section.

THE FRITTS PLACE.

Less than one-half of a mile south of the Conrad openings, two small circular ones have been made in the same granite on the Fritts place. The openings are in an old field with no exposures of the granite nearby. The granite is probably slightly finer in texture than that of the Conrad place, but it is of the same color and contains about the same proportion of biotite. The rock quarried on this place is reported to have been used in the court-house building in Lexington.

One mile north of Lexington on the Greensboro road and in front of the Leonard residence is a good section exposing the decay to a depth of about 8 feet. The decay is light gray, slightly yellowish brown in color, in which the original minerals of the fresh granite are easy of determination. The feldspars are more or less kaolinized, chalky-white, and dull in appearance. Biotite flecks of a general brassy color and brittle, indicating more or less leaching from chemical action, are abundantly distributed through the mass.

THE SINK PLACE.

Two miles south of Lexington and one-quarter of a mile east of the Lexington-Linwood road, directly on a small stream is an opening about 100 feet long by 36 feet wide and 25 to 40 feet deep in a slightly schistose granite. The opening is practically of the same size as the flat-surface exposure of the granite in which it is made.

The rock is a fine-grained, gray, biotite granite in which the schistose structure is apparent. Excepting the slightly schistose structure, it is similar in all respects to the granite described above on the Conrad place to the north of Lexington. Schistosity is probably more emphasized in the weathered rock in which a slight "augen" appearance is evident. The stone quarried from this opening is reported to have been used in Lexington and vicinity for various purposes.

Microscopical Examination.—The microscope shows an aggregate of feldspar and quartz with biotite. The feldspar is principally orthoclase with much plagioclase and no microcline. Carlsbad twinning is common. Peripheral shattering is very pronounced in fine-grained mosaics of quartz and feldspar completely surrounding the larger grains and filling the interstices of these minerals. Biotite has its principal distribution along and in the quartz-feldspar mosaic. Chlorite, epidote, and colorless mica are alteration products derived from the biotite. Additional iron oxide, titanite, apatite, and zircon occur.

About a quarter to a half mile south of the Sink opening and directly on the road a more gneissic phase of the same rock is exposed from grading. It is very irregular in structure, usually fine-grained, somewhat thinly schistose with "augen" of white and pink feldspar. A pronounced tendency toward segregation into irregular wavy lines or bands in the biotite is exhibited.

Microscopically, a thin section of the rock shows essentially the same mineral composition and structural features as that nearby in the Sink opening. Several scattered grains of microcline were noted. Crushing from dynamic metamorphism is greatly more emphasized in the thin section of this rock than that nearby at the Sink opening. Biotite is the chief accessory and shows the usual alteration products.

The rock exposed at this point can only be used in very rough grades of work.

Porphyritic Granite.

Beginning about $3\frac{1}{2}$ miles west of Lexington, on the Mocksville road, partially decayed, light gray, biotite granite of somewhat variable texture—fine to coarse grain—with slight porphyritic ten-

dency in places is exposed. Within a short distance westward the rock becomes typically porphyritic in texture and is continuously traced along the road by means of its decay into Davie County to Advance Station and beyond, a distance of 18 miles west of Lexington. No exposures of the entirely fresh rock were seen but the decay is typical, completely preserving the porphyritic texture of the fresh granite, and it affords equally as ready a means of tracing the area as the fresh rock. Variation in the decay is from light gray to yellowish red with the feldspar phenocrysts still intact but much kaolinized. In the lighter colored decay the biotite has suffered but little alteration, but in the deeper colored areas much chemical alteration of this constituent is evident.

The phenocrysts are usually of large size, flat tabular to irregular in outline, and they exhibit the usual Carlsbad twinning. Inclusions of biotite are quite conspicuous.

The decay of this granite indicates a medium to coarse-textured, biotite, porphyritic granite, resembling in all respects the similar rock described in other parts of this report from Gaston, Iredell, Cabarrus, and Rowan counties. None of the fresh rock was procurable, hence further definite statements cannot be made.

Dikes of Basic Igneous Rocks.

Dike rocks of basic composition are common over many parts of Davidson County. In mineral types these rocks are essentially the same as for the adjoining counties, diabase, diorite, and more basic ferromagnesian types are the most common. To the west of Lexington, dikes of diabase penetrating the granite have been noted at the following points along the Mocksville road: One and a quarter and $6\frac{1}{2}$ miles, respectively, west of Lexington; in the bed of a small stream, $7\frac{3}{4}$ miles west of Lexington; and $1\frac{1}{2}$ miles west of Lexington along the same road a narrow belt of basic ferro-magnesian rocks occur. In the field the rock is coarse-textured, light to dark green in color, in which feldspar is not apparent megascopically.

For several miles to the north of Lexington along the Greensboro road numerous greenstone schist dikes of variable width are exposed, striking in a general northwest direction. Similar ones are observed along the same road at many points between Lexington and Thomasville, and between Thomasville and High Point. About 5 miles south of High Point in the extreme northeast corner of Davidson County, the greenstone dikes are very abundant and are completely thinly schistose. From this point into High Point, Guilford County, both large and small dikes of diabase are frequent.

The much altered greenstone schist dikes apparently indicate a series of intersecting basic igneous rocks of a much earlier period of intrusion than the entirely massive unaltered diabase dikes of the same area.

DAVIE COUNTY.

The principal granite areas of Davie County are largely limited to the eastern half of the County, which represent the westward extension of similar rocks over the contiguous part of Davidson County, described above. Both even-granular and porphyritic granites of the biotite type are known. In addition to these is a single occurrence of a rather uncommon and peculiar textured orbicular rock. The characterizing accessory in this type of rock is amphibole without biotite. A complete description of the rock is given below.

With the single exception of a few stones quarried on the Peter Hairston estate prior to the Civil War to supply certain local needs on the plantation, no granite has been quarried in Davie County.

THE YADKIN RIVER GRANITE AREA.

The Even-Granular Granite.

THE HAIRSTON PLACE.

To the northwest, west and southwest of the Peter Hairston residence in the middle eastern part of Davie County, near the Yadkin River and about 7 miles east of Advance Station, on the Charlotte-Winston branch of the Southern Railway, an extensive area of a fine-textured light gray biotite granite is traced from numerous exposures. About a quarter of a mile northwest of the Hairston residence, three or four small surface openings, near together, were made prior to the Civil War in flat-surface exposures of the granite. Only the surface stone was quarried and the openings indicate a rather advanced stage of decay in the rock. The rock quarried was used for various purposes in and about the Hairston residence. Although considerably weathered, it is safe to say that the fresh rock would prove to be a desirable granite for many grades of work. At the openings the granite is of uniform fine texture, gray in color and biotite-bearing.

THE COOLEEMEE COTTON MILLS.

In the extreme southern portion of Davie County and extending into the contiguous portion of Rowan County, along the South Yadkin River, 13 miles northwest from Salisbury, numerous exposures of granite occur, especially at the Cooleemee Cotton Mills. The granite is exposed

in the bed of the river under the cotton mills' dam and on the two sides of the stream. The dam was built of the stone quarried from these exposures of the granite, and the rock has also been used to a limited extent for bridge piers.

The rock is a medium coarse-textured granite, schistose in structure, and partially decayed to the depth of the openings from which only surface raises have been made. The feldspars are in an advanced stage of kaolinization and the rock readily crumbles into a medium coarse-textured granitic sand when subjected to slight pressure. Three sets of joint-planes intersect the granite exposed near the dam, striking about N. 45° E., N. 45° W., and N.-S.

Microscopical Examination.—A thin section cut from a specimen of the rock collected under the dam at the Cooleemee mills showed under the microscope a biotite granite composed of both fine and coarse interlocking aggregates of quartz and feldspar. Orthoclase, microcline, and striated plagioclase make up the feldspathic constituent. The biotite is much altered, principally to epidote. Irregular rounded areas of micrographic intergrowths of quartz and feldspar are distributed through the section. The larger quartz and feldspar individuals are completely enveloped by a very fine mosaic of the same minerals derived from intense pressure-metamorphism.

Porphyritic Granite.

In the vicinity of the exposures of the even-granular granite described above the same rock grades into coarse textured porphyritic granite of the same mineral composition, which is described above as extending from 3½ miles west of Lexington in Davidson County to and beyond Advance, a station on the Charlotte-Winston branch of the Southern Railway. As previously stated, the area is readily traced by the residual decay of the granite which, in sections along the road, varies from a light gray to red, thickly studded with the large kaolinized feldspar phenocrysts, which occupy the exact positions in the decay as in the fresh rock.

The phenocrysts vary from small and large irregularly rounded, to prevailingly flat-tabular, idiomorphic crystals invariably twinned on the Carlsbad law and containing abundant inclusions of the groundmass biotite. Over most of the area the surface is thickly strewn with the altered phenocrysts, which are usually broken into smaller pieces by splitting along the cleavage planes.

The groundmass of the rock is a coarse-textured dark gray granite containing, as a rule, an increased percentage of biotite over the even-textured facies.

*Orbicular Gabbro-Diorite.*²²

Ten miles west of Lexington and one mile west of Oaks Ferry on the Yadkin River, are exposures of the orbicular diorite, which are less than a half mile east of north from the Hairston residence. These are in huge boulder form occupying a low indistinct ridge, which culminates in a peak or knoll about 30 feet in elevation above the surrounding plain. It is on this knoll that the typical orbicular rock is exposed in immense boulders covering probably as much as one or two acres of surface (see Fig. B, Pl. XVII).

Traced in a southwest direction from the knoll or peak is found complete evidence of the extension in that direction of the orbicular rock. In the residual decay, with occasional partially decayed fragments of the rock scattered over the surface. The decay is of a pronounced, nearly dark black color, with a decided greenish tone, imparted by the ferromagnesian constituent of the fresh rock. Oxidation of the iron is nowhere apparent. The zone of decay averages several hundred yards in width, as nearly as could be determined, and extends a half to three quarters of a mile southwest of the knoll. On each side of this narrow zone of decay sharp contacts between it and the porphyritic granite were observed in a number of places. The conditions, as closely as they could be traced and made out over the surface, leave practically no reasonable doubt that the orbicular rock occurs in the form of a typical dike penetrating the porphyritic granite and whose trend is northeast and southwest. It is practically parallel with and intersects the same rock as some half-dozen large dikes of massive and unaltered diabase in the vicinity, and is probably to be referred to the same age.

Away from the knoll of exposed masses of the typical orbicular texture, the rock assumes a pronounced granitic texture or rather coarse texture and composed of the same minerals. There is a marked tendency in places toward the orbicular texture, with spheres very small and perhaps more nearly of the same size, less than one quarter of an inch in diameter. In other words, the rock presents two distinct and strongly contrasted phases, namely, orbicular and granitic.

The color of the rock is dark with a greenish tone imparted by the dark green bisilicate. Viewed in detail, it presents a pronounced mottled appearance made up of dark green nodules of hornblende set close together and in many cases touching each other, with the inter-nodular areas filled with clear white, cleavable and highly lustrous feldspar. The

²² Orbicular Gabbro-Diorite from Davie County, North Carolina, by Thomas L. Watson, *Journal of Geology*, 1904, Vol. XII, pp. 294-303.

nearly black green nodules strongly contrast with the intensely white feldspar. As a rule, the spheres are well rounded varying in size from an eighth of an inch to, in extreme cases, several inches in diameter. As is seen in Plate XVIII, the dark spheres of the hornblende make up the bulk of the rock. The spheres show a tendency more or less strongly toward a fibrous radiating structure from a common center outward and, megascopically, are composed entirely of the dark green hornblende. In a few cases a small fragment of white feldspar forms the center around which the dark silicate arranged itself. Also quartz and pyrite have both been observed as the nucleus about which the spheres of the dark green mineral were formed.

The structure of the spheres in the Carolina rock is markedly different from that of such bodies usually observed in orbicular rocks described from Europe and the United States. In these a more or less pronounced concentric structure is observed in the minerals composing the spheres, some of the layers of which show in part at least the radiate fibrous arrangement. Still a second difference is in the composition of the spheres. As a rule, the spheres of orbicular granite and diorite hitherto described are composed of several minerals, generally the principal constituents of the groundmass, with, in many cases, additional minerals not present to any appreciable extent in the groundmass. Also, difference in color is observed from the center to the margin of the spheres, dependent upon the predominant mineral in any given portion of the sphere. In the Carolina rock a tendency toward radiate rather than concentric structure is indicated; composed of only one mineral, and of a single uniform color throughout.

In the feldspar areas there are many large laths of the dark bisilicate of idiomorphic tendency, penetrating the feldspar without respect to orientation. A quarry is being opened up in this rock by the Consolidated Granite Co. of Winston-Salem, N. C.

Microscopical Character of the Rock.—Six thin sections were prepared from selected chips of the rock for microscopical study. Five of the sections were cut from the nodules and one from a representative fragment of the interstitial filling or matrix. The character of the sections was such that only slight evidence was afforded of the structure of the nodules microscopically, but the radial arrangement of the minerals composing the nodules about a common center is entirely clear in hand specimens of the rock, as indicated in the megascopic description above.

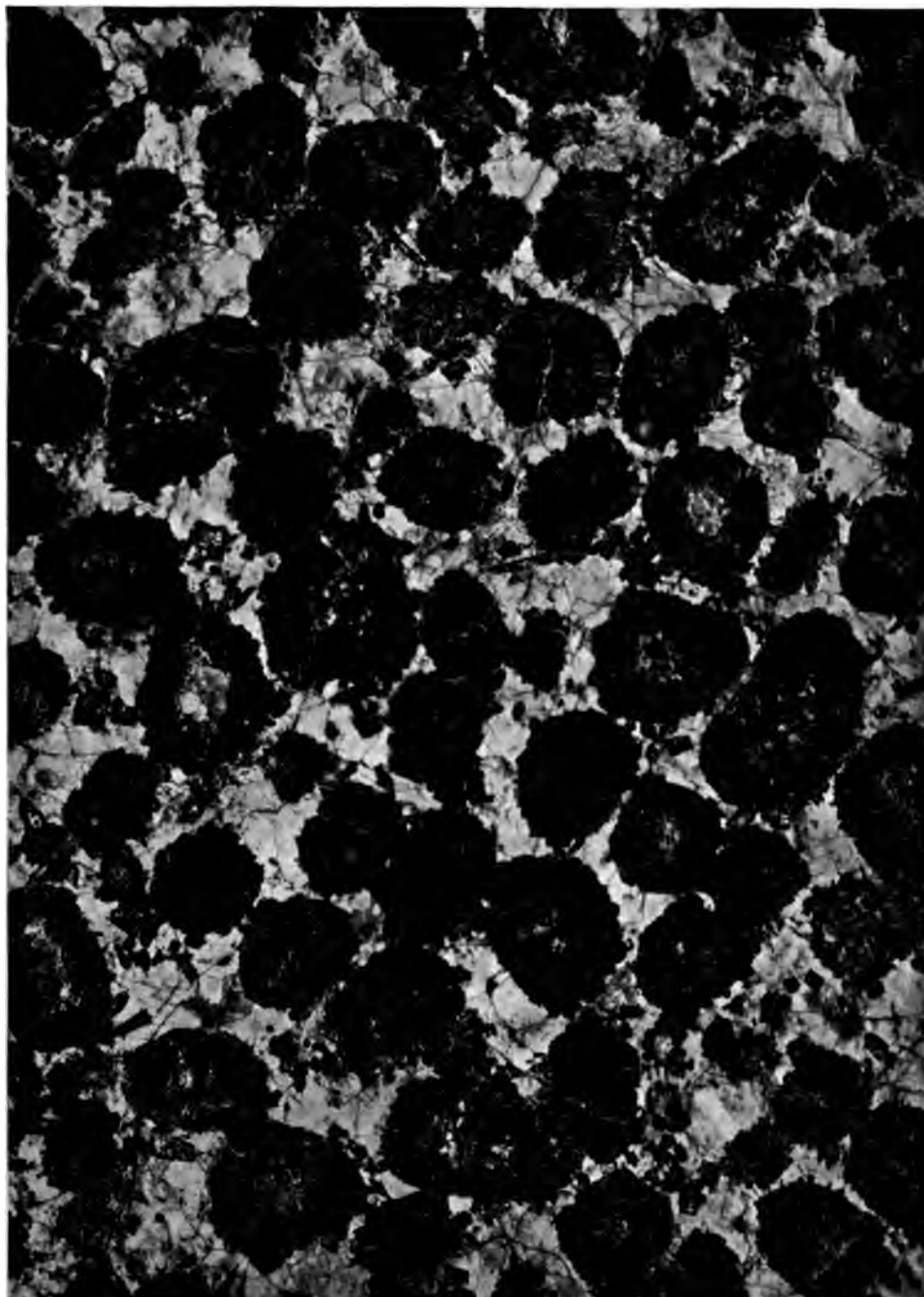
Diallage, green hornblende, basic plagioclase, microcline, quartz, titanite, muscovite, calcite, zoisite, magnetite, and an occasional zircon are the principal minerals of the rock. Essentially the same minerals are observed, as a rule, in both the matrix and the nodules, but in dif-



A. QUARRY NO. 1, ROWAN GRANITE COMPANY, $4\frac{1}{2}$ MILES SOUTHEAST OF SALISBURY, SHOWING GRANITE DECAYED TO DEPTH OF 10 FEET.



B. BOULDER OUTCROP OF ORBICULAR GABBRO-DIORITE, HAIRSTON FARM, DAVIE COUNTY, 10 MILES WEST OF LEXINGTON, DAVIDSON COUNTY.



PHOTOGRAPH OF POLISHED SURFACE OF ORBICULAR GABBRO-DIORITE SHOWING THE SPHERES OF DARK GREEN HORNBLLENDE.

curs in irregular grains without crystal outline. In thin section the color is pale to moderately deep brown, with slight absorption in the deeper-colored crystals. It is usually free from inclusions of other minerals. Cleavage is rather pronounced in much of it.

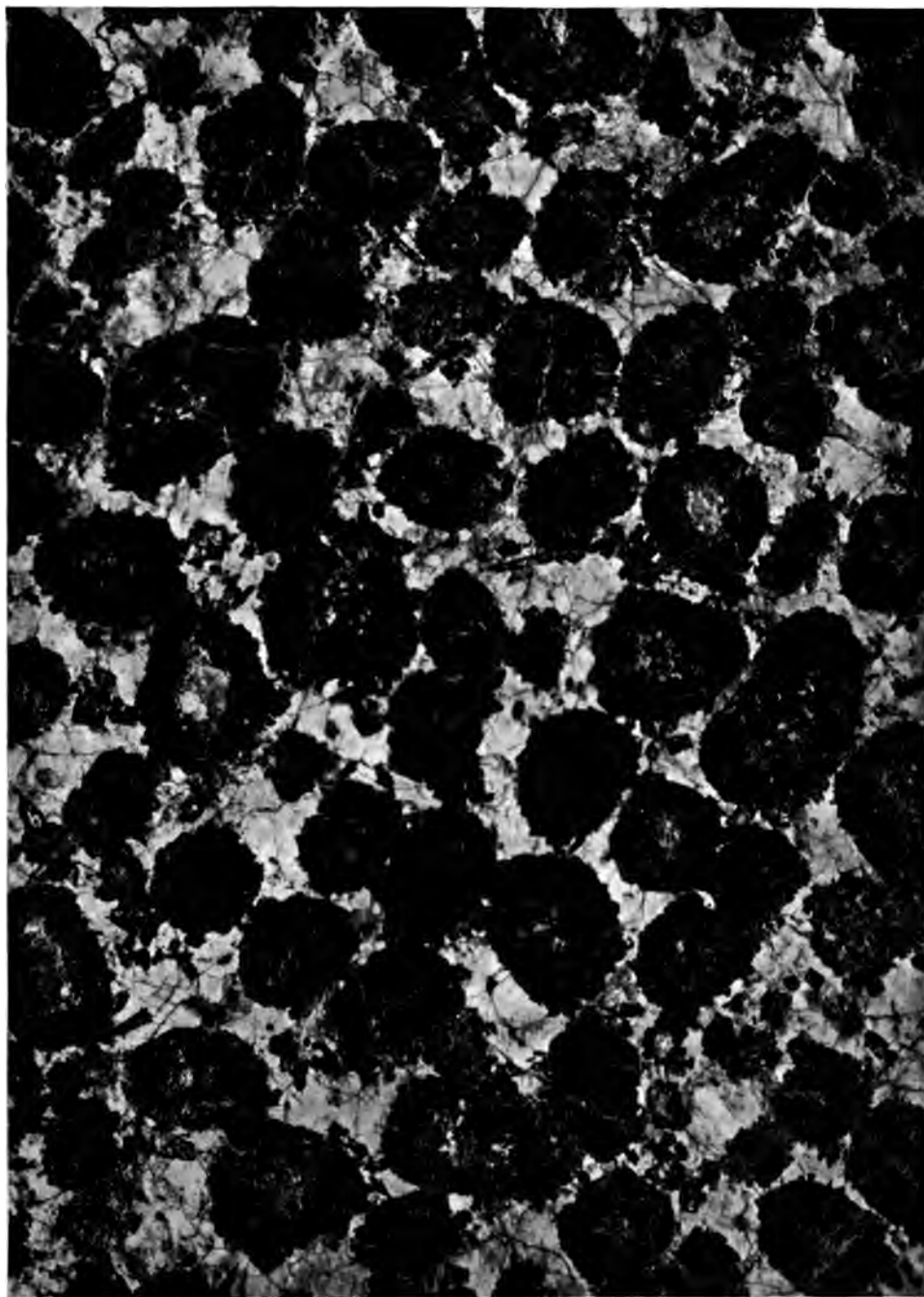
Quartz is present in very subordinate amount in many of the sections, and it is probably largely, if not entirely, secondary. Muscovite and calcite are wholly secondary, and as such they present no noteworthy features. Magnetite and an occasional zircon complete the list of minerals.

Summing up the results of the microscopic study, we find that the sections consist essentially of diallage, uralitic hornblende, and a basic plagioclase, showing, as a rule, but slight polysynthetic twinning, and usually altered to muscovite and calcite, or to zoisite and muscovite. The presence of perfectly fresh microcline in subordinate amount, a little quartz which is probably secondary, and a relatively large amount of accessory titanite and apatite is characteristic. Clearly the rock is a gabbro-diorite, although the presence in some of the sections of microcline and quartz is unusual.

Several of the large boulders capping the knoll have been split and some of the stone has been worked up for various purposes. Prior to the Civil War, Mr. Peter Hairston, owner of the property, had a sufficient amount of the stone quarried to erect two very handsome gateposts at the front approach to his premises and for steps to the house. The rock dresses well under the hammer and as indicated by specimens in the building-stones collection in the State Museum at Raleigh, it is susceptible of high polish. No signs of decay are indicated in the stone used at the Hairston residence, although quarried many years ago. On a polished surface of the stone the effect is unique and beautiful, and the rock should prove to be of considerable value for ornamental and decorative purposes.

On observing the weathered surfaces of the rock in the natural exposures, the feldspar is apparently the first mineral to go to pieces, as the spheres are picked up over the surface in a nearly fresh condition. The loose spheres picked up over the surface show little or no oxidation of the iron in the hornblende, but they contain the color of the nearly fresh rock.

A polished column and sphere of this unique stone formed a part of the State exhibit at the Louisiana Purchase Exposition, held in St. Louis in 1904.



PHOTOGRAPH OF POLISHED SURFACE OF ORBICULAR GABBRO-DIORITE SHOWING THE SPHERES OF DARK GREEN HORNBLENDE.

occurs on the Charles place. The exposure covers an area of 60 by 80 yards and has an average slope of about 14 degrees. By the stripping of the slight depth of decay, the dimensions of the area could be largely increased. A surface raise was made over a small part of the outcrop some years ago and the stone was worked into curbing and sills for use in Winston-Salem.

The rock is a medium coarse-textured biotite porphyritic granite of light gray color. It is slightly schistose in places, and two sets of joint-planes penetrate the rock, striking N. 45° W., and N. 50° E. Most of the feldspar phenocrysts are roughly rounded and of more or less irregular outline, which with decrease in size grade into the same ground-mass constituent. Many of the phenocrysts, however, show idiomorphic, flat-tabular outlines, one-half inch in length by one-eighth inch across; they exhibit Carlsbad twinning and contain biotite inclusions.

Microscopical Examination.—Under the microscope, a thin section of the rock indicates a biotite granite whose principal minerals are orthoclase, microcline, micropertthitic intergrowths, quartz, and biotite. Plagioclase is only sparingly present. Secondary muscovite, chlorite, and epidote, with a slight sprinkling of certain minor accessories, complete the list of minerals. In the larger feldspar individuals, the micro-poikilitic texture is well developed, the included minerals consisting largely of the other feldspar species. Irregular areas of micrographic intergrowth of quartz and feldspar are quite freely distributed through the thin sections. The biotite is largely altered to chlorite, some epidote, and much colorless mica.

About one-quarter of a mile west of the opening the granite is cut by a small diabase dike, exposed in the Lexington road.

Outcrops of the partially decayed granite are observed along the road from near Winston south to the Charles place. The residual decay is typical and it affords a ready means of tracing the rock. Between Winston and the Charles opening the rock is an even-granular granite which grades southward into the porphyritic facies.

About 5 miles southeast of Winston, on the Nissen place, are exposed some half dozen acres of flat-surface masses of a fine-textured, medium gray granite-gneiss. The area is crossed by a small stream which gives a gentle slope of the granite-gneiss exposures on either side, toward the stream. A single small opening was made near the stream in one of the exposures some years ago, and a few stones were quarried for local use in Winston-Salem. Several similar exposures of the same rock occur nearby.

The rock is a biotite granite of schistose structure, and at the open-

Basic Igneous Intrusive Rocks.

Excepting the dike of orbicular diorite described above and the area about Cooleemee cotton mills in the extreme southern part of the County on the South Yadkin River, only diabase dikes have been observed over those portions of Davie County studied during the past field season. These dikes are all similar in composition, completely massive and unaltered, except by superficial decay. They have been observed at the following points and in every place they penetrate the granite.

Three-quarters of a mile west of Oaks ferry on the Yadkin River, two parallel dikes several hundred yards apart are exposed on the Mocksville road, trending N. 30° E., and 8 and 100 feet wide, respectively, penetrating the porphyritic granite. One-half mile south of the same road and 1½ miles west of the ferry, a diabase dike with northeast trend and about 75 feet wide cuts the granite and passes directly through the north corner of the Hairston yard, where boulder exposures are observed. A second dike with the same trend and not less than 100 feet wide is exposed 300 yards north of the Hairston residence. Still a third dike of diabase having the same trend and width and intersecting the granite is exposed between the last dike and the Mocksville road.

FORSYTH COUNTY.

The principal areas of granite in Forsyth County are limited to the southeastern and eastern portions of the County, extending from near Winston southward and eastward into Guilford and Davidson counties. Outcrops of the fresh rock are not frequent but the granite is readily traced by its residual decay at the surface. Both porphyritic and even-granular biotite types of the granite are represented and the two textures grade one into the other, representing different facies of the same mass of similar mineral composition. Over the other parts of the County the principal rocks are schists and gneisses whose origin is yet in doubt.

No quarries have been regularly worked in the County but several small openings have been made in somewhat widely separated outcrops, a few miles to the south and east of Winston, to supply a local demand for the stone in the above city.

THE WINSTON GRANITE AREA.*Porphyritic Granite.*

About 5 miles south of Winston and one-fourth of a mile east of the Lexington road, a surface exposure of a light gray porphyritic granite

occurs on the Charles place. The exposure covers an area of 60 by 80 yards and has an average slope of about 14 degrees. By the stripping of the slight depth of decay, the dimensions of the area could be largely increased. A surface raise was made over a small part of the outcrop some years ago and the stone was worked into curbing and sills for use in Winston-Salem.

The rock is a medium coarse-textured biotite porphyritic granite of light gray color. It is slightly schistose in places, and two sets of joint-planes penetrate the rock, striking N. 45° W., and N. 50° E. Most of the feldspar phenocrysts are roughly rounded and of more or less irregular outline, which with decrease in size grade into the same ground-mass constituent. Many of the phenocrysts, however, show idiomorphic, flat-tabular outlines, one-half inch in length by one-eighth inch across; they exhibit Carlsbad twinning and contain biotite inclusions.

Microscopical Examination.—Under the microscope, a thin section of the rock indicates a biotite granite whose principal minerals are orthoclase, microcline, micropertthitic intergrowths, quartz, and biotite. Plagioclase is only sparingly present. Secondary muscovite, chlorite, and epidote, with a slight sprinkling of certain minor accessories, complete the list of minerals. In the larger feldspar individuals, the micro-poikilitic texture is well developed, the included minerals consisting largely of the other feldspar species. Irregular areas of micrographic intergrowth of quartz and feldspar are quite freely distributed through the thin sections. The biotite is largely altered to chlorite, some epidote, and much colorless mica.

About one-quarter of a mile west of the opening the granite is cut by a small diabase dike, exposed in the Lexington road.

Outcrops of the partially decayed granite are observed along the road from near Winston south to the Charles place. The residual decay is typical and it affords a ready means of tracing the rock. Between Winston and the Charles opening the rock is an even-granular granite which grades southward into the porphyritic facies.

About 5 miles southeast of Winston, on the Nissen place, are exposed some half dozen acres of flat-surface masses of a fine-textured, medium gray granite-gneiss. The area is crossed by a small stream which gives a gentle slope of the granite-gneiss exposures on either side, toward the stream. A single small opening was made near the stream in one of the exposures some years ago, and a few stones were quarried for local use in Winston-Salem. Several similar exposures of the same rock occur nearby.

The rock is a biotite granite of schistose structure, and at the open-

ing contains some small grains and crystals of garnet distributed through it. Jointing is not conspicuously developed and at the opening only one set of planes could be positively determined, which indicated a strike of N. 80° W.

Gneiss.

About 3 miles east of Winston on the Maston place, and several hundred yards east of the Southern Railway near the Maston residence, a small opening was made some years ago in an outcrop of gneiss, and the rock was used in the construction of a bridge over one of the neighboring streams. The stone is unsuited for any purpose save that of rough work.

The rock is an irregularly banded, dark biotite gneiss of variable composition and texture. Some of the bands are highly feldspathic while in others this constituent apparently entirely fails. In places the rock assumes a typical schistose aspect of the biotite type; in others the gneissic phase is strongly developed and made up of alternating quartz-feldspar bands with darker colored ones of biotite. The rock is garnetiferous in places.

Microscopical Examination.—A thin section cut from a representative specimen of one of the gneiss bands showed, under the microscope, a rock of granitic composition, containing orthoclase, much plagioclase, quartz, and biotite as the principal constituents. Biotite is of the usual kind much altered to chlorite, and considerable muscovite derived from the alteration of the feldspar, occurs associated with more or less kaolin. The texture is rather coarse, and strain shadows and fractures in the larger quartz and feldspar individuals indicate the action of dynamic forces.

From the opening on the Maston place west to Winston, 3 miles, the decay along the road and in the railroad cuts indicate the same rock penetrated by narrow dikes, and veins of granitic composition and of fine texture.

Diabase Dikes.

Dikes of massive diabase are rather frequent over the areas studied in Forsyth County. About one-quarter of a mile west of the Charles granite opening and crossing the Lexington road, 5 miles south of Winston, is a diabase dike penetrating the granite, less than 50 feet wide with an approximate north-south strike. One and a half miles east of Winston is a second dike of diabase about 25 feet wide and striking a few degrees west of north, which is exposed on both sides of the road.

Microscopical Examination.—Microscopically, a thin section cut from a hand specimen of the last dike, shows the rock to be a typical olivine diabase, composed of long, very thin blades of plagioclase, with the interstices filled with small idiomorphic crystals of augite, magnetite and olivine. The ophitic structure is most characteristically developed.

Within the northwest limits of Winston-Salem, in a cut along the Mocksville branch of the Southern Railway, is an unaltered massive diabase dike 200 feet wide and striking N. 20° E., as nearly as could be determined. About three-quarters of a mile southwest of Bethania, a station on the Wilkesboro branch of the Southern Railway, and eight miles northwest of Winston-Salem, a very large diabase dike is exposed penetrating mica schist. The dike, where exposed, has a width of 200 to 500 feet and trends N. 20° E. At the point where examined, the dike apparently conforms to the schistosity of the enclosing schist and does not cut across it as in most cases. Results of tests of this rock for road material are given on page 265.

GUILFORD COUNTY.

The principal granite areas of Guilford County are confined to the western, northern and central portions of the County. Indeed they are extensive over the entire west half of the County. With one exception, the granites are of even-granular texture and carry biotite as the chief characterizing accessory. The exception is that of a porphyritic granite occurring near Friendship in the middle western part of the County. Examination of the granite outcrops in all parts of the County indicates that they have more or less of the schistose structure developed in them, with some additional evidence of crushing and mashing from pressure-metamorphism.

Regular quarries have nowhere been worked in the County but openings have been made in many places to obtain stone of a certain grade for local use. The granites of Guilford County are best treated separately under the following five areas: The Brown Summit Area; The Summerfield Area; The Friendship Area; The Jamestown Area; and the Greensboro Area.

THE BROWN SUMMIT GRANITE AREA.

One and a half miles southeast of Brown Summit, a station on the main line of the Southern Railway, and 10½ miles slightly east of north from Greensboro, on the Walker Place, are flat surface exposures of a light gray schistose granite, extending over several acres of

surface. Westward in a direct line the railroad is reached at a distance not exceeding $\frac{3}{4}$ of a mile. Some of the granite was reported to have been first quarried prior to the Civil War for use on the Walker place as steps, blocks, etc. It was more extensively worked later for stone to be used on the streets and in some of the buildings in Greensboro, and to some extent in bridge construction.

The rock is a biotite granite, schistose in structure, and contains much muscovite in places. It is quite variable in texture and color and is penetrated by very many veins and dikes of pegmatite, composed largely of feldspar and quartz with a sprinkling of biotite. These intersect the rock in nearly all directions, but probably a majority of them conform to a N. 60° E. direction, and a second direction at approximately right angles to this one. The veins are sometimes observed cutting across each other with a displacement of several inches. The principal jointing strikes N. 60° E., and the surfaces of the joints are more or less completely slickensided. On account of the shearing and schistose structure and the rather numerous veins, the use of the granite is limited to the lower grades of work.

Microscopical Examination.—Microscopically, a thin section of the rock from this place shows a biotite granite of fine texture, composed of an aggregate of quartz, microcline and orthoclase with very scant plagioclase, and some biotite altered in part to chlorite. Effects of pressure-metamorphism are pronounced through the section. A few scattered grains of black magnetite occur.

Between this area of schistose granite on the Walker Place and Gray's Mill, one mile south, the country rock is a basic greenstone much crushed and mashed and closely jointed. It is otherwise altered in its mineral constituents which makes it uncertain as to what it was originally.

Nine miles north of Greensboro on the Reidsville road, flat-surface outcrops of a variable biotite gneiss are exposed for some distance along and on both sides of Rogers Branch. The rock is a dark hornblende-biotite gneiss of irregular schistosity, and variable in texture and composition. It contains a large proportion of the dark silicates and its variable character makes it unsuited for any but rough grades of work. It is penetrated in many places, at close intervals, by very thinly schistose greenish black basic rock in the form of dikes not exceeding 18 inches in width and striking in a general northeast direction.

Microscopical Examination.—A thin section of the schistose rock indicates under the microscope a hornblende-biotite gneiss in which hornblende is more abundant than the biotite. The hornblende shows some leaching and considerable alteration to the "reedy" form. Biotite dis-

plays its usual color and absorption and is closely associated with the hornblende. The quartz and feldspar, the former greatly in excess, form very fine granular interlocking mosaics distributed along more or less parallel lines between layers of the dark silicates, emphasizing the gneissic structure.

The rock northward between this point and Gray's Mill on Reedy Fork, and along the Reidsville road, is a variable mica schist, largely sericitic, as indicated by the residual decay. Beginning $5\frac{1}{2}$ miles north of Greensboro and extending northward $3\frac{1}{2}$ to 4 miles along the Reidsville road to the exposures of gneiss described above on Rogers creek, the country rock is a variable mica schist ranging from sericitic to quartzitic in composition.

THE SUMMERFIELD GRANITE AREA.

Summerfield is a station on the Sanford and Mt. Airy branch of the Southern Railway, and is 12 miles northwest of Greensboro. About 6 miles west of Greensboro on the Battle Ground road, a medium fine textured biotite granite outcrops on both sides of the road. The rock has been opened both on the north and the south sides of the road to obtain macadam for the road. The granite is continuous westward from this point to and beyond Summerfield, a distance of 6 miles. It is porphyritic in places but the rock over the greater portion of the area is an even-granular granite, the two textures representing different phases of the same granite mass. The granite is penetrated by a number of diabase dikes to the east of Summerfield, along the Greensboro road.

THE HOSKINS PLACE.

About a quarter of a mile south of Summerfield, on the Hoskins place, large boulder outcrops of a fine textured, schistose, biotite granite are exposed over several acres of surface. The granite appears entirely massive in places but it exhibits a pronounced schistose structure in others. In the schistose portions of the rock the banding is irregular and, in places, is contorted and crumpled. Two sets of joints intersect the rock striking N. 10° E., and N. 70° E.

A small opening has been made in one of the exposures and some of the stone was quarried for local use. The rock is not suited for the better grades of work in which granite is used.

Microscopical Examination.—Under the microscope, a thin section of the rock shows a fine-textured biotite granite of closely interknit feldspars and quartz in which lie small, irregular shreds of biotite largely

altered to chlorite. Single plagioclase individuals are absent and the feldspar content is composed of potash varieties and microperthitic intergrowths. No injurious minerals occur.

THE GAMBLE PLACE.

One mile southwest of Summerfield, on the Gamble place, a flat doming granite mass is exposed along a tiny stream, from which some stone has been quarried. Blocks and curbing were quarried for use on the streets of Greensboro. The rock is well adapted for this purpose, but as shown in the description which follows it is not a desirable granite for the better classes of work in which granite is used. The opening is approximately 50 yards square with a quarry-face of about 12 feet in depth.

The rock is a biotite granite of variable color, texture and structure. Variation is from medium fine even-grained to medium coarse-grained porphyritic granite; from massive to schistose in structure; and from light to medium dark gray in color. The schistose structure is rather marked in places and very many dark irregular segregation areas of biotite are contained in the rock.

Microscopical Examination.—Thin sections cut from specimens of this rock show microscopically a medium fine-grained biotite granite composed of an aggregate of complexly interlocking feldspar and quartz in which lie the irregular shreds of biotite altered in part to chlorite and a colorless mica. Peripheral shattering is indicated in one of the sections. Potash feldspars with microperthitic intergrowths and very sparse plagioclase compose the feldspathic constituent. Both micrographic intergrowths of feldspar and quartz and micropoikilitic structure in some of the feldspar are well developed. No injurious minerals were noted in any of the thin sections.

So far as exposed, the porphyritic phase of the granite predominates over the even-granular texture. The feldspar phenocrysts are both irregular roughly rounded in outline and flat-tabular, one-half to 2 inches in length by one-half inch wide and frequently twinned on the Carlsbad law.

About 3 miles northeast of Summerfield, in the vicinity of Flat Rock church and near the railroad, some blocks for street purposes are reported to have been quarried in an outcrop of granite similar to that on the Gamble place. The writer was unable to visit this opening.

The granite is continuously traced by its residual decay in a north-south direction between Summerfield and Friendship, a distance of 10 miles. It is typically porphyritic in places, and grades into the even-

granular granite of the same mineral composition. Dikes of diabase intersect the granite at several points along the road between Summerfield and Friendship. About half-way between the two stations and about three-quarters of a mile north and northwest of Pleasant Ridge church, the even-textured biotite granite has been opened to a very slight extent in several places.

THE FRIENDSHIP GRANITE AREA.

Friendship is a station on the Wilkesboro and Winston-Salem division of the Southern Railway and is 10 miles west of Greensboro.

THE MCGRADY QUARRY.

Three miles N. 25° E. from Friendship, two openings about half a mile apart in an east-west direction have been made in outcrops of biotite granite, and some of the stone has been quarried. The openings are reported to have been made many years ago to obtain stone for building culverts along the railroad. The openings are small and represent only surface stripping, worked to a depth not exceeding 8 or 10 feet.

The rock is a porphyritic biotite granite of variable texture and color, and of rather inferior quality. The amount of biotite is rather large in places and perhaps a dark gray color prevails.

Microscopical Examination.—A thin section of the rock collected from the east opening indicates, under the microscope, a biotite granite composed of the following principal materials: quartz, orthoclase, much plagioclase, micropertitic intergrowths, biotite, titanite, zircon, apatite, chlorite, and muscovite. Biotite is rather abundant, associated with the titanite and containing large inclusions of prismatic zircon. Micrographic and micropoikilitic structures are developed.

Outcrops of the granite are reported between Friendship and Oak Ridge, and in the vicinity of the latter, 5 miles northwest of Friendship, and within a few miles of the Forsyth County line. Likewise the granite is traced by its decay for some distance along the road from Friendship eastward toward Greensboro.

THE JAMESTOWN GRANITE AREA.

One-half mile southeast of Jamestown on Bull Run, an opening was made some years ago in a ledge exposure of granite-porphry for stone to build a culvert over Bull Run at the railroad crossing. A few hundred paces further down the stream a second smaller opening has been made in the same rock.

The rock is a fine-grained, dark gray, thinly schistose granite-porphry, composed of bluish opalescent quartz, white opaque feldspar and biotite. The mass is penetrated at close intervals by two sets of joints which strike N. 40° W., and N. 20° E. It cannot be used for general building purposes because of the close jointing not admitting of dimension stone being quarried; otherwise it is an excellent rock, possessing great hardness and toughness.

Microscopical Examination.—A thin section of the rock from this opening, examined under the microscope, indicated a distinct granite-porphry. The section shows an exceedingly fine-grained groundmass of quartz and feldspar with some biotite largely altered to chlorite, much epidote, and a colorless mica, in which are embedded porphyritic crystals of plagioclase (oligoclase) and orthoclase feldspars, and one or two of quartz. The phenocrysts show no tendency toward orientation and those of feldspar are filled with dust-like inclusions and are otherwise much altered, principally into muscovite shreds. Some magnetite and leucoxene very sparingly occur.

A few hundred feet north of the opening the granite-mass is penetrated by a diabase dike which strikes N. 40°-50° W. Boulders of the dike are exposed over the surface on both sides of the mill road, a quarter of a mile west of the opening.

OAKDALE COTTON MILL.

One mile southeast of Jamestown at the Oakdale cotton mills, on Deep River, large boulder and ledge exposures of a very similar rock to that described above on Bull Run are observed. Much blasting was necessary in the construction of the dam across the river at the cotton mills, affording excellent exposures of the granite. The granite area is a large one and wherever exposures were observed the rock was more or less schistose in structure. Dark areas of segregated biotite of irregular outline and variable size are frequent in the rock.

The rock is of medium texture, somewhat resembling that exposed on Bull Run except that it is coarser in texture, more schistose in structure, and the quartz is not of the blue opalescent kind. Where exposed at the dam across Deep River, 4 parallel dikes of what is apparently diabase penetrate the granite, from 1 to 15 feet in width and conforming to a N. 20° E. strike. The contacts between the dikes and the enclosing granite are perfectly sharp where observed in exposures of the fresh rock. The dike rock is very fine grained and more or less schistose in structure. Results of tests of these rocks for road material are given on page 265.

Microscopical Examination.—A thin section cut from a specimen of the rock collected at the dam of the cotton mills on Deep River, showed, under the microscope, a biotite granite of medium texture. The principal mineral composition of the rock is potash and plagioclase feldspars, quartz and biotite, with some peripheral shattering from dynamic forces indicated. Orthoclase is the predominant feldspar associated with much plagioclase and very little microcline. Both the feldspar and the biotite show more or less alteration of the usual kind. A few scattered grains of magnetite occur and slight development of the micropoikilitic structure in some of the feldspar is noted.

THE MODLIN QUARRY.

Four miles northeast of High Point and $1\frac{1}{2}$ miles southeast of Jamestown on the H. C. Modlin place, a rather extensive opening was made some years ago in a fine to medium-grained granite to obtain stone for building bridges and culverts along the Southern Railway, which passes within a short distance of the Modlin property. The opening was worked to a considerable depth and a large amount of the stone is reported to have been quarried.

The rock is a fine to medium grained biotite granite of medium to dark gray color, and fairly uniform in both color and texture. It is a desirable granite for many purposes, and so far as an examination reveals, it contains no injurious minerals. Numerous outcrops of granite are exposed over the Modlin place, but as yet only the single opening has been made.

Microscopical Examination.—A thin section of the rock from the quarry opening on the Modlin place showed, microscopically, a biotite granite of medium fine texture. The principal minerals are, much plagioclase and orthoclase feldspars, quartz, and biotite, with no identified microcline. The usual accessories common in granite occur with no injurious ones noted. Effects of dynamo-metamorphism manifested in fractures, strain shadows and some peripheral shattering are rather marked in the thin section.

THE GREENSBORO GRANITE AREA.

THE CITY QUARRY.

This quarry is located about $1\frac{1}{4}$ miles north of the court-house in Greensboro. The opening, worked in August 1903, was about 350 by 100 feet and 6 to 8 feet deep. The rock was being quarried at the time for macadam and the method used was blasting with

dynamite, which shattered the stone so much as to destroy the value of the rock in the opening for any other purpose. A rock crusher was being operated at the quarry for sizing and grading the stone. Results of tests of this rock for road material are given on page 265.

The rock is a medium coarse-grained biotite granite, massive in structure and of medium gray color. It is quite uniform in both color and texture and it is of pleasing appearance but dimension stone cannot be quarried because of the close jointing. The strike of the joints is N. 20° E., N. 50° E., and N. 20° W. Slickensided surfaces are well developed along the jointing. The rock displays the effects of crushing and fracturing from pressure metamorphism, and it is penetrated by a number of dark greenish black amphibolite dikes. The dikes vary from a few inches to 18 inches in width and are parallel, cutting the granite at irregular intervals and conforming to a N. 20° E. strike, which is coincident with the jointing in that direction.

Microscopical Examination.—A thin section prepared from a specimen of the rock collected from the City quarry shows, microscopically, a biotite granite of medium texture. Nearly equal striated plagioclase and orthoclase with very little microcline, quartz and biotite make up the essential minerals in the section. The feldspars are all more or less completely clouded from alteration. Biotite is largely altered to chlorite and epidote, and a very slight sprinkling of magnetite grains occurs. No injurious minerals were noted in the thin section.

THE COUNTY QUARRY.

The County quarry is located near the ball grounds in the northeast limits of the city of Greensboro on the Cone property. The rock is a variable textured diorite penetrated by numerous dikes of altered diabase. The rock has been much crushed from pressure metamorphism and both it and the dikes are closely jointed, the surfaces of some of which are slickensided. The joint-planes strike N.-S., E.-W., and N. 40° W. The dikes vary in width from a few inches to nearly 50 feet with small stringers penetrating outward from the dikes into the diorite. Results of tests of this rock for road material are given on page 265.

Variation in the diorite is from a coarse nearly black rock, in which the hornblende is in large, partially idiomorphic crystals, to one of a medium-fine even grain. The feldspar content varies considerably from place to place, imparting a lighter color to the rock where it is present in maximum amount.

Microscopical Examination.—A thin section of the rock from the County quarry shows under the microscope a typical diorite, composed

of much large platy hornblende of greenish blue color with slight pleochroism accompanied by the separation of much black magnetite grains as inclusions, and short, stout laths of striated plagioclase. The hornblende is principally an altered or "reedy" form.

A thin section prepared from a specimen of the rock penetrating the diorite in the form of dikes shows, microscopically, a uralitic diabase, of rather fine grain. The original augite is almost entirely altered to the "reedy" form of hornblende. Long, slender laths of plagioclase indicate more or less tracing of the diabase structure. Magnetite is quite freely distributed through the section.

The dimensions of the opening are approximately 300 by 150 feet and worked to a depth not exceeding 12 feet. A rock crusher was operated at the quarry and the stone was used for macadam purposes. Four to 5 feet of a deep red, and stiff residual clay derived from the decay of the diorite covers the fresh rock in places in the quarry sections shown, which it is necessary to strip before quarrying.

Along the Reidsville road, $3\frac{3}{4}$ to $5\frac{1}{2}$ miles northeast of Greensboro, the rock is of decided dioritic composition and appearance and is closely jointed. It affords some evidence of having been mashed and squeezed from pressure metamorphism and is penetrated by innumerable veins and dikes of granitic composition. A thin section of as fresh a specimen of the rock as it was possible to obtain indicated under the microscope such extreme alteration that very little satisfactory evidence as to its petrography could be made out. So far as it was possible to interpret it, there seemed to be not much question of referring it to a diorite.

About $5\frac{1}{2}$ miles northeast of Greensboro along the same road are exposures of a partially decayed fine-textured, light gray biotite granite, displaying pronounced effects of pressure metamorphism and close jointing. For this reason, the rock is entirely unsuited for any purpose, except as road material and ballast.

INTRUSIVE DIKE ROCKS OF BASIC COMPOSITION.

Basic intrusive rocks are somewhat numerous over all parts of Guilford County. The principal types include diabase and diorite, and their altered products, greenstone and amphibolite. Both massive and schistose structures are represented in the rocks and on this basis not all of the dikes belong to the same period of intrusion; but several periods are represented. In all cases the rocks are typical of the kinds represented and megascopically they do not display any unusual noteworthy features.

Diabase Dikes.

Diabase forms perhaps the most frequent type of basic igneous rock of Guilford County. The most important dikes noted are as follows: One mile west of Greensboro near the cemetery on the Battle Ground road a dike of diabase 100 feet wide and striking in a general northeast direction penetrates the granite²²; City quarry, 1½ miles north of Greensboro, a parallel series of diabase dikes striking N. 20° E., and varying from a few inches to 18 inches wide; 2½ miles southwest of Greensboro on the Spring Garden road is a narrow dike striking approximately northwest; 3¼ miles northeast of Greensboro is a dike 15 feet wide striking north and south, exposed along the Reidsville road.

About 10½ miles east of north from Greensboro and three-quarters of a mile northeast of the Hardy residence, where the Doggett mill road crosses a small stream is a dike 200 feet wide striking north and south. Three miles east of Greensboro on the Rankins saw-mill road is a dike about 25 feet wide and striking in a northwest direction. Between the Guilford Battle Ground and Summerfield, 12 miles northeast of Greensboro, a number of small dikes penetrate the granite and are exposed along the road, for several miles southeast of Hamburg's mill. At the mill 3 miles southeast of Summerfield a large dike is exposed with a probable northeast strike. Between Friendship and Summerfield, a north-south distance of 10 miles, the granite is penetrated at a number of points along the road by diabase dikes.

On the Greensboro road, 3 miles northeast of High Point, a dike 25 feet wide and striking northeast is exposed. Between Deep River and Jamestown is a second dike of the same width and strike. On the east side of the railroad at Jamestown is a third dike with the same strike; width not determined. At the quarry on Bull Run, one-half mile southeast of Jamestown, is a large dike striking N. 40°-50° W. At the dam across Deep River, 1 mile southeast of Jamestown, the granite at the Oakdale cotton mill is intersected by a series of parallel dikes²³ varying from 1 to 15 feet in width and striking N. 20° E. To the south of High Point along the Lexington road the rocks are penetrated by numerous dikes, the largest one of which is 600 feet wide. The diabase dikes in this locality have a general approximate northwest strike.

Diorite.

To the north of Greensboro, diorite forms one of the most important rock types, where extensive areas of it are developed in places. The rock

²² Results of tests of this rock for road material are given on page 265.

is best exposed at the County quarry, within the northeast limits of the city of Greensboro. One mile west of Greensboro and near the cemetery on the Battle Ground road, a diorite dike 18 feet wide and striking northeast penetrates granite within 100 feet of a large diabase dike having the same strike. Results of tests of this rock are given on page 265. Microscopic study of a thin section of this rock indicates a typical diorite.

Greenstone Dikes.

These are altered basic igneous rocks derived probably from both diabase and diorite, and they are usually more or less schistose in structure. They are regarded as being older in age than the dikes of massive diabase and diorite described above. The best exposures of these rocks are seen at the following places: Along the Battle Ground road between Greensboro and the cemetery. They are partially decayed and schistose and in width vary from 2 to 4 feet. On the Greensboro road, at Deep River bridge, one-quarter of a mile west of Jamestown, is a completely schistose dike more than 100 feet wide and striking northeast. For several miles east of Greensboro along the Ashboro road very many dikes of greenstone schist are exposed penetrating the granite decay. Seven miles northeast of Greensboro at Rankin's saw-mill large boulders of greenstone outcrop on both sides of the stream. The rock is porphyritic in places and projecting stringers or veinlets penetrate the granite rock on the southwest side of the stream along the road. Still another area is mentioned above between the Walker place and Grays mills, 9 to 10 miles east of north from Greensboro along the Reidsville road.

Amphibolite.

Along the Reidsville road immediately on the south side of Rogers Branch, hornblende-biotite gneiss is intersected by a number of thinly schistose dikes composed largely of hornblende, the width of which do not exceed 18 inches, and which have a northeast strike.

Gabbro.

Along the Ashboro road, near Sharps school-house, $2\frac{1}{2}$ miles southeast of Greensboro, is a dike of coarsely crystalline basic eruptive rock, probably not less than 1,000 feet wide and having a general northeast direction. Large boulder outcrops of the rock are exposed for a quarter of a mile southeast of the school-house. The boulders have been quarried to a slight extent in several places for macadam.

Microscopical Examination.—Microscopically, a thin section of the rock showed much colored augite with faint pleochroism filled with grains of magnetite, hornblende, with the feldspar areas completely altered to a fine mosaic of different minerals. Results of tests of this rock for road material are given on page 265.

ALAMANCE COUNTY.

THE BURLINGTON GRANITE AREA.

Granites of irregular color and texture are found in the vicinity of Burlington, the county-seat, principally to the north, east, and southeast of the town. The outcrops are very few and small, and the rock is identified and traced mainly by its residual decay, which covers the fresh rock to some depth and consists usually of a light gray, sometimes red, siliceous to clayey soil. The rock is schistose in places, always biotite-bearing and of little value except in the ordinary lower grades of work. The color varies from nearly white, in which little or no biotite occurs, to medium and dark gray containing a goodly proportion of biotite. In texture, variation is from moderately coarse to fine-grained.

A number of very small openings have been made in places to obtain stone for purely local purposes. About 4 miles north of Burlington, small quantities of the granite have been quarried from time to time for window and door sills in factories of that vicinity. Again, to the east of Burlington, $1\frac{1}{2}$ miles just off and to the north of the Haw River road, a small opening has been made in a schistose granite of variable structure, texture and color, for use as macadam. Near the southeast limits of the town a small amount of stone was quarried from a surface stripping of a small exposure of the granite. The rock at this point also lacks uniformity in color and texture.

Microscopical Examination.—Microscopic study of a thin section of the rock collected from the opening near the southeast limits of Burlington indicated a biotite granite, composed of a medium coarse aggregate of quartz and feldspar, in which lie altered shreds of biotite. Microcline entirely fails and striated plagioclase equals in amount orthoclase, both of which are largely altered to epidote and some other less important accessories. The quartz occupies distinct areas through the section. No injurious minerals are indicated under the microscope.

THE HALL PLACE.

About 3 miles north of Burlington and a quarter of a mile northwest of Glencoe, a small quantity of stone has been quarried from an exposure of granite on the Hall place. The rock is a biotite granite of

rather irregular texture and color, mostly medium-grained and gray in color. The exposure is a small one and the stone, so far as developments indicated, is not of very desirable quality, though it can be used to advantage for many purposes.

Microscopical Examination.—Microscopically, the rock is a medium-grained biotite granite, composed largely of orthoclase with a small quantity of both plagioclase and microcline, quartz and biotite. Biotite was rather sparingly distributed through the section and several grains of pyrite were noted. The micropoikilitic structure was well developed in some of the larger feldspar individuals.

THE ALTAMAHA GRANITE AREA.

Altamaha is the name given to an area of syenite-porphry exposed along Haw River and its tributaries, especially Reedy Fork, at the Altamaha and the Ossipec cotton mills, about $7\frac{1}{4}$ miles northeast of Burlington. The nearest railroad point is Elon College, a station on the Greensboro-Goldsboro branch of the Southern Railway, distant about 5 miles south of the area.

The two mills, Altamaha and Ossipec, are about one mile apart in an approximate north-south direction. The first exposure of the rock is observed at the bridge along the river on the opposite or south side from Altamaha, and is traced from this point southward to the Ossipec mills, where large outcrops occur on both sides of the stream. The exposures are in the nature of ledge and boulder outcrops along the streams, and as boulder and flat surface masses between the streams. On the opposite or north side of Reedy Fork from the Ossipec mills extensive ledge and boulder exposures of the stone occur from which much of the rock was quarried about 5 years ago, and used principally for constructing the dams across the streams at the mills. The strike of the joint-planes at this point is N. 10° E., and N. 60° - 70° W. The rock is further penetrated by some veins of pegmatite, but not sufficiently abundant nor of large enough size to in any way interfere with the quarrying of desirable dimension stone. In places, pyrite in large and small irregular masses and grains is quite freely distributed through the rock. Blocks of the stone of any dimension are obtainable from these exposures. A few stones have been obtained recently from a very small opening made in an exposure of the rock directly in front of the new brick church between the two mills, but nearest Altamaha.

Megascopically, the rock is a compact, exceedingly hard, fine-grained, dark gray syenite-porphry. The feldspar phenocrysts are not large and

are accordingly not conspicuously developed in the rock. To the north of the Ossipee mills, in front of the church and at the bridge at Altamaha, the texture of the rock is even-granular or non-porphyrific. Both the color and the texture of the rock are quite uniform. The rock is quite lively and pleasing in appearance and is a very desirable stone for general building and other purposes. It is very hard and tough and would probably increase the cost of quarrying somewhat above the general average for true granites.

Microscopical Examination.—Microscopically, a thin section of the rock exposed in the openings made on the opposite side of the stream from the Ossipee mills showed a fine-grained biotite syenite-porphyry. Named in order of their abundance the groundmass minerals are orthoclase, oligoclase, biotite, muscovite, epidote, magnetite, leucoxene, pyrite, and some crypto-crystalline quartz. Idiomorphic striated plagioclase (oligoclase) and some orthoclase, with fewer biotite phenocrysts are imbedded in the groundmass.

A similar section cut from the rock exposed at the bridge opposite Altamaha, indicated microscopically the same rock, but of non-porphyrific texture and much altered. The amount of biotite and short, stout laths of a striated feldspar is increased over that at the Ossipee mills. The minerals are, named in order of their abundance, orthoclase, biotite, oligoclase, epidote, muscovite, magnetite, and leucoxene.

BASIC IGNEOUS ROCKS.

Rocks of basic igneous type are very abundantly distributed over portions of Alamance County. These may be divided conveniently into two classes, namely, greenstones which are more or less thinly schistose, altered volcanics extensively exposed over the eastern half of the County, and especially well exposed along Haw River at the Haw River station to the east of Burlington about 4 miles; and dikes comprising principally diabase, diorite and gabbroitic forms. The dikes are numerous exposed along the principal roads to the south and the east of Burlington, and again between Burlington and Altamaha. They are especially well developed in the vicinity of Glencoe and further north in the direction of the Altamaha granite area.

About one mile northeast of Haw River station, and a quarter of a mile north of the Macadam road, a recent opening has been made in a flat-surface exposure of the greenstone. The rock was quarried for use in macadamizing the roads. It is very tough, much crushed and mashed from dynamic forces, closely jointed and more or less schistose in struc-

ture. A rock crusher and classifier is located at the opening for crushing, grading and sizing the stone for macadam. Results of tests of this rock for road material are given on page 265.

**RÉSUMÉ OF THE GRANITES OF THE CAROLINA IGNEOUS BELT.
(THE MAIN GRANITE BELT.)**

Briefly summarizing the important points developed in the descriptions of the individual granite areas of the Main Granite Belt of the State, it is shown first, that granite is one of the principal and most wide spread rocks found within the limits of the belt. Extensive areas of granite are exposed more or less in each of the 10 counties included within the belt and, in each county some stone has been quarried from time to time, usually to satisfy only an immediate local demand. Notwithstanding the wide distribution of granite over the belt, only one county within the belt has undertaken systematic quarrying, namely, Rowan. In this county quarrying has been confined to the Dunns Mountain granite ridge and its southwestward extension to the east and the south of Salisbury, where the earliest quarrying antedates many years the Civil War.

Texturally, two distinct phases of the granite are developed, an even-granular or normal, and a porphyritic granite, both of which have wide distribution within the limits of this belt. With only one exception the two textures represent different phases of the same rock mass, the porphyritic texture grading into the even-granular. The single exception is in the Mooresville granite area of Iredell County, where the field evidence conclusively indicates that the even-granular granite represents a separate intrusion in the porphyritic granite, although the two texturally unlike rocks are essentially identical in all other respects.

Over most of the belt the granite shows more or less distinct evidence of the effects of intense dynamic-metamorphism, in many instances resulting in the partial or complete development of a secondary schistose structure. In the thin sections of the rock from those areas in which the granite appears massive to the unaided eye, more or less pronounced effects of pressure-metamorphism are indicated by the microscope.

Variation in color is from nearly white through the lighter to darker shades of gray, according to the proportion and character of distribution of the dark minerals, biotite with or without hornblende. To the east and southeast of Salisbury, in Rowan County, a beautiful shade of pink granite is quarried in several places over Dunns Mountain and its southwest extension. In the even-granular granite the texture varies from fine to medium, rarely coarse.

Mineralogically, the granites are hardly without exception mica-bearing (biotite) with, in several places, considerable hornblende associated with the biotite. At a number of localities in the southern and northern parts of Mecklenburg County, hornblende constitutes the principal accessory in the granite with only a small amount of biotite noted. In still a few other places over the belt, muscovite is sparingly developed as a primary constituent in association with the biotite in the rocks.

Microscopically, the most noteworthy feature of the granites in this belt is the large percentage of plagioclase feldspar present in the rocks. Only in a few sections does plagioclase occur in very subordinate amount, while in most of the thin sections studied this constituent is in large amount equalling or even exceeding the potash feldspars. The extinction angles measured on the twinning lamellæ indicate either a very acid oligoclase or albite or both as the species of plagioclase feldspar present. Both orthoclase and microcline are generally present and frequently in nearly equal proportion. A majority of the thin sections studied indicated an overlapping in the periods of crystallization of the feldspar and the quartz, in the rather numerous areas of micrographic intergrowths of the two minerals. Micropoikilitic structure is invariably partially or well developed in the feldspars, the inclusions consisting largely of feldspar species different from the host, and quartz. This structure seems oftentimes best developed in those sections of the granites which show the largest development of the micrographic intergrowths of quartz and feldspar. The usual primary and secondary accessory minerals common to granites are noted in the rock.

Weathering of the granites as well as the other types of the rocks is widespread and profound over the area, yielding the usual decayed products common to such rocks. In case of the granites the early stage of weathering is represented by a very light gray granitic sand, in which the principal minerals of the fresh rock manifest but slight chemical decay and are readily distinguished in the decay. This stage is characterized, as a rule, by very slight or no oxidation and is largely the result of physical agents producing the disintegration of the rock. The advanced stage of decay consists of a highly oxidized, deep red, ferruginous, gritty clay, in which the minerals of the fresh rock are usually not distinguishable. The product represents an advanced stage in weathering promoted largely by chemical agents producing crumbling by decomposition. Between these stages of weathering of the granites all intermediate gradations may be readily traced. The result of this weathering is that, with some exceptions, the rocks both granite and other types are usually mantled to some depth with a loose,

residual decay. However, outcrops of the firm and hard moderately fresh granite are by no means uncommon over the area, and, as a rule, the exposures are large enough to admit of the opening of large quarries without much stripping.

Within the limits of the Main Granite Belt are found large quantities of very desirable stone well suited for many purposes for which granite is used. The belt is traversed in nearly all directions by lines of railroad which offer ready and ample facilities for transportation and make quarrying possible in any county within the limits of the belt.

THE WESTERN PIEDMONT GNEISS AND GRANITE BELT.

GENERAL DESCRIPTION.

The rocks of Western Piedmont North Carolina are composed largely of schists and gneisses of the mica type. These show considerable variation in composition and texture where examined and are probably to be referred in large part to sedimentary origin. A part of the gneisses, however, are certainly altered igneous masses whose structural resemblances to sedimentary masses are due to the effects of dynamo-metamorphism.

Besides these there are areas of both acid and basic igneous rocks invading the gneiss-schist complex. Among the acid type of igneous rocks are massive and schistose granite covering workable areas over many parts of the belt. The more important areas of these rocks are found in Surry, Wilkes, Alleghany and Alexander counties. There are other areas in other counties in this belt, but as far as known, they are of little economic importance.

At present granite quarrying in this belt is limited exclusively to Surry County, where in the vicinity of Mt. Airy, the county-seat, one of the largest quarrying industries in the State is being rapidly developed. In Alexander, Wilkes and Alleghany counties are found extensive areas of very desirable granite for certain grades of work which doubtless will be developed in the near future.

SURRY COUNTY.

The principal outcrops of granite in Surry County are found in the northern part of the County near the Virginia line, in the vicinity of Mt. Airy, the county-seat. The granite outcrops in flat-surface exposures immediately to the north and south of the town of Mt. Airy, and is exposed in an advanced stage of decay in places within the limits of the town (see Pl. XIX).



GENERAL VIEW OF MT. AIRY GRANITE QUARRIES.

Quarrying on rather an extensive scale has been conducted for some years in the exposures found a short distance north of Mt. Airy, and to-day it forms one of the most active quarrying centers in the State. The entire quarry operations are under the control of one company, known as the North Carolina Granite Corporation.

THE NORTH CAROLINA GRANITE CORPORATION (MT. AIRY QUARRIES).

These are the only quarries worked in Surry County and they are located $\frac{1}{4}$ to 1 mile northeast of Mt. Airy. The quarries were first opened in 1889, in which year the Mt. Airy Granite Company was incorporated, and the first shipment of stone from the quarries was made in July, 1890. The quarries were operated by the Mt. Airy Granite Company from the very beginning up to the first of January, 1898, when the property was leased to Thomas Woodroffe & Sons, who operated the quarries continuously up to July 1, 1904. In July, 1904, the entire business was sold to the North Carolina Granite Corporation, which is now actively engaged in developing and operating the business. The accompanying tabular statement shows the amount of stone shipped from these quarries in carload lots from 1890 to 1904 inclusive * (Pl. XXIV).

Shipments of granite from the Mt. Airy Granite Quarries, 1890 to 1904:

Year.	Carloads.
1890	135
1891	264
1892	334
1893	523
1894	952
1895	834
1896	548
1897	1044
1898	1333
1899	1474
1900	1113
1901	1055
1902	1138
1903	1203
1904	1282

The openings are made in a forty-acre tract of nearly continuously exposed granite over the slope and top of a long hill, which rises in elevation about 125 feet above the valley-bottom, in which a railroad track is laid and operated between the quarries and Mt. Airy. The bulk

* Through the courtesy of Mr. Thomas Woodroffe.

of the granite exposed over this tract has been stripped. The deepest working has a depth of about 30 feet from which four or five raises of the rock of different thicknesses have been removed. In other openings only two raises have been worked, and, over most of the exposure, only the first raise (surface) has been made (Pls. I and XX). These will vary in thickness, affording quarry-faces which range from 10 to 12, 5 to 6, and 3 to 4 feet in depth, respectively. In August, 1903, a new opening was being worked for blocks and curbing on top of the hill and near the northern limits of the exposure, which showed a quarry face averaging $3\frac{1}{2}$ feet in depth and 315 feet long (Fig. A, Pl. XXI).

The average angle of slope of the exposed granite from the base to the top of the hill is 12 degrees, which is readily taken advantage of in facilitating easy quarrying. The distance between extreme openings in an east-west direction is 2,300 feet. In addition to the 40-acre tract to which the quarrying operations are confined, the Company owns more than 200 acres over which the granite outcrops but in which no openings have yet been made (see Pl. XIX).

The rock is a very light gray nearly white biotite granite, of medium texture, containing no visible injurious minerals. Feldspar, quartz, and biotite characterize the rock megascopically. The biotite is not, except in one opening, equally distributed through the rock, but is entirely absent from some parts; is uniformly distributed through others and shows a marked tendency to segregation areas in still other parts of the granite. Quartz-feldspar areas of extreme whiteness, ranging from several inches to as many feet in diameter, from which all biotite is entirely absent or only a few shreds are occasionally noted, are frequent through the rock. This unequal distribution of the characterizing accessory renders the stone in places less uniform in color than might be desirable for some purposes. Where uniformity of color obtains, the rock is most pleasing in appearance and forms excellent and desirable stone for all purposes to which granite is put, except for monumental stock, in which the contrast of color is not great enough between the cut and polished faces.

In the recent opening made on top of the hill and near the northeast limits of the exposure, these irregularities are almost entirely absent and the color of the granite is quite uniform, affording a high grade of granite for general building purposes.

Veins and dikes usually found in most granites are nowhere visible in the Mt. Airy quarries, and visible jointing is almost entirely lacking. The granite is tight in the mass and when quarried yields or breaks, with



NORTH CAROLINA GRANITE CORPORATION'S QUARRY, $1\frac{1}{2}$ MILES NORTH OF MT. AIRY, SURRY COUNTY, SHOWING METHOD OF STRIPPING AND WORKING OFF THE SURFACE SHELF FROM A PART OF THE RIDGE SLOPE.

perhaps one or two exceptions, along an irregular twisted or warped quarry-face.

Microscopical Examination.—Under the microscope thin sections of the Mt. Airy granite show the presence of the usual granite minerals, such as quartz, feldspar, light and dark micas, zircon, apatite, epidote, chlorite, and very little iron oxide. Both the quartz and the feldspar are in relatively large size individuals, the interstitial areas between which are filled, in one of the sections, by a fine-grained mosaic of the same mineral, suggesting peripheral shattering from pressure metamorphism. Orthoclase is in excess of microcline in all of the sections examined, accompanied by a large proportion of a finely striated acid plagioclase. The large quantity of both acid plagioclase and microperthite will doubtless account for the large excess of soda over potash in the analysis of the granite given below. Zonal structure and Carlsbad twinning are beautifully developed in some of the feldspars. Quartz is of the usual granite kind, and forms occasional intergrowths of micrographic structure with feldspar in all of the sections. Biotite is deep brown and strongly pleochroic and is altered to chlorite, a colorless mica, and some epidote. Much muscovite as an alteration product derived from both the feldspars and biotite is present (see Fig. A, Pl. II).

The composition of the Mt. Airy granite is indicated in the following chemical analysis:*

Analysis of granite, Mt. Airy, N. C.

SiO ₂	70.70
Al ₂ O ₃	16.50
Fe ₂ O ₃	2.34
MgO	0.29
CaO	2.96
Na ₂ O	4.56
K ₂ O	2.45
FeS ₂	0.09
Total	99.89

The crushing strength of this granite is well shown in the following tests[†] made on specimens of the stone by different parties and at different places:

(I) Crushing tests made on specimens of the Mt. Airy granite

* Lewis, J. V., Notes on Building and Ornamental Stone, First Biennial Report of the State Geologist, 1891-1892 (1893), p. 94.

† Furnished through the courtesy of Mr. R. Percy Gray, Greensboro, N. C., President of the Mt. Airy Granite Co. The entire interests of this Company were sold in July, 1904, to the North Carolina Granite Corporation.

at the U. S. Navy Yard, Washington, D. C., April 16, 1896; Charles O'Neil, commander U. S. Navy and Bureau of Ordnance U. S. Navy: (II) at the testing department of the Philadelphia Scale and Testing Machine Works, Philadelphia, Penna., Nov. 4, 1895; Riehle Bros.

Crushing strength of Mt. Airy granite.

(I.)

Marks.	Size of block.	Crushed at.	Strain per square inch.
M. A. 1	2" cube.	80,725 pounds.	20,488 pounds.
M. A. 4	2" "	86,450 "	21,292 "
M. A. 7	2" "	90,780 "	22,469 "
M. A. 10	2" "	84,410 "	20,686 "
M. A. 13	2" "	80,000 "	19,703 "
M. A. 16	2" "	74,870 "	18,384 "
		Mean	20,497 "

(II.)

Size of block.	Crushed at.	Strain per sq. inch.
2" cube.	79,000 pounds.	19,750 pounds.
2" "	80,350 "	20,088 "
2" "	81,600 "	20,400 "
	Mean	20,076 "

Specimens broke suddenly with loud report, several large pieces and a lot of fine material resulting from each test.

Two tests, made by Professor F. P. Venable, of the University of North Carolina, at Chapel Hill, October 24, 1895, as to the capacity of the Mt. Airy granite for absorbing water, yielded the following results:*

	No. 454	No. 455
Weight when dried	830.4	1001.7 grams.
Soaked in water 24 hours and then allowed to		"
dry in air 24 hours. Weight.....	830.8	1002.1 "
Weight of water absorbed in 24 hours.....	0.4	0.4 "

As Professor Venable remarks, neither sample shows noteworthy porosity nor absorbing power for water.

The tests enumerated above, both physical and chemical, made on specimens of the Mt. Airy granite amply suffice to show the marked resistance of the granite to the normal atmospheric forces, and its durability when placed under such conditions. Results from microscopical examination of thin sections of the granite are in accord with these tests.

*Furnished through the courtesy of Mr. R. Percy Gray, Greensboro, N. C., President of the Mt. Airy Granite Co.; since July, 1904, known as the North Carolina Granite Corporation.



A. NORTH CAROLINA GRANITE CORPORATION'S QUARRY, MT. AIRY, SURRY COUNTY, SHOWING THICKNESS OF SHEETS WORKED.



B. ROCKY-FACE MOUNTAIN, 4 MILES NORTHEAST OF HIDDENITE, ALEXANDER COUNTY, AN UNREDUCED RESIDUAL OF GRANITE-GNEISS.

The Company is well equipped with all necessary modern machinery and appliances for quarrying and handling the stone. The present owners of the quarries, the North Carolina Granite Corporation, are making some very extensive improvements. In 1905, a large stone cutting plant was being erected, which will be equipped with the most modern stone-breaking appliances. The present expenditure for these improvements will approximate \$75,000, with ample provision made for future development of the enterprise. The stone is handled from the quarries to the railway cars by a system of inclined cable-ways, the stone being sent down the hill to the cars by gravity. The railway cars are operated over a track at the foot of the hill near the quarries and the town of Mt. Airy. The limit of dimension stone is the capacity of the railroad cars. Blocks weighing 20 tons are reported to have been frequently shipped from the quarries (see Pls. I and XIX).

The granite from the Mt. Airy quarries is marketed over a large territory as attested by the following principal points to which it has been shipped for use in both the rough and the dressed state: Many of the principal cities and towns in Pennsylvania, of which Philadelphia is the largest market; Cincinnati and Manchester, Ohio; Baltimore, Maryland; Washington, D. C.; many of the principal cities and towns in Virginia and North Carolina; and to Memphis and other towns in Tennessee. In Plate XXII there is shown the entrance to Greenwood Cemetery, Lancaster, Pa., which is built of Mt. Airy granite.

All the stone used in the large dry dock at Newport News, Virginia, the largest dry dock in the world, and the concreting material used in the Fort Caswell fortifications, Cape Fear River, North Carolina, came from the Mt. Airy quarries. The bulk of the granite from these quarries, however, is reported to be used in the form of blocks and curbing for street purposes. Much of it is also reported to be used for general building purposes. Further uses of the granite have been in the form of cemetery curbing, street crossings, and railroads for bridge coping. The quarry-waste is utilized for concreting, roofs on cotton mills, macadam on streets and roads, ballast along the railroads, and in granolithic work. Results of tests of this rock for road material are given on page 266.

The method of quarrying the stone consisted, in August, 1903, in drilling a hole about 3 inches in diameter perpendicular to the surface to a depth of the thickness of the stone desired, usually 5 to 7 feet, and then fired by a succession of light blasts, using in the first charge about a handful of blasting powder. The operation is begun by discharging about $\frac{1}{4}$ of a pound of dynamite in the bottom of the hole. This small

charge of dynamite pulverizes the stone slightly at the bottom of the hole and forms a small chamber. The tamping is then cleaned out of the hole, and the hole is recharged in the same manner, this time, however, using about a handful of powder. Recharging of the hole is continued with small charges of powder until a small seam has been started at the bottom of the hole, extending parallel with the surface. This is found out by using a small steel rod bent at the lower end and sharpened to a point, and passing it up and down the hole until the crack is located. After the crack has once been started, the use of light charges of powder is continued, increasing the charges gradually as the seam is found to extend in all directions from the lift hole, until the crevice extends a distance of 75 feet or more from the hole. The use of explosives is discontinued and a water-tight connection is made to the hole by cutting off a piece of iron pipe of suitable length, which is fastened in the hole with melted sulphur. To this connection is attached an ordinary hand force pump and water is pumped into the crevice already formed by the explosives. No difficulty is found in extending the crevice by continuous pumping of the water until finally it covers an area frequently as much as two acres in extent, and finds vent or relief by tearing out to the thin edges on the side of the hill. This process is used in the warmest weather when the surface of the rock is naturally somewhat expanded and more easily raised. It is very doubtful whether this method could be employed to work the stone during cold weather. Experience shows that hotter the weather the easier it is to work the stone in this manner. No difficulty is had in raising sheets of the stone in this manner covering areas of from one to two acres and from 6 to 8 feet in thickness close to the hole. After the pump is once started it requires only a few hours of steady work to force the sheet out to the thin edge. It is found necessary to entirely clean off a ledge of stone made in this manner before attempting to form or raise another sheet on the surface below. For this reason the quarries cover considerably more area than one having natural seam beds (see Pl. XXIV).

Although the North Carolina Granite Corporation found that the substitution of water under pressure for powder after the cleavage has extended some little distance from the drill hole was an improvement, they were not satisfied and experimented with compressed air, with the result that they found that compressed air was as much of an improvement over water as the water was over powder. The method of employing compressed air is described by Mr. Thomas Woodroffe, vice-president of the company, as follows:



CEMETERY ENTRANCE AT LANCASTER, PA., MADE OF MT. AIRY GRANITE.

In the center of the sheet or area to be lifted a drill hole 2 to 3 inches in diameter is sunk 6 to 8 feet in depth, depending on the greatest thickness of stone required, and the operation is continued by the discharge of successive small amounts of powder similarly as described under the method of quarrying by using water until the crevice extends a distance of 75 feet or more from the hole in all directions. A pipe is then cemented into the hole and connected by

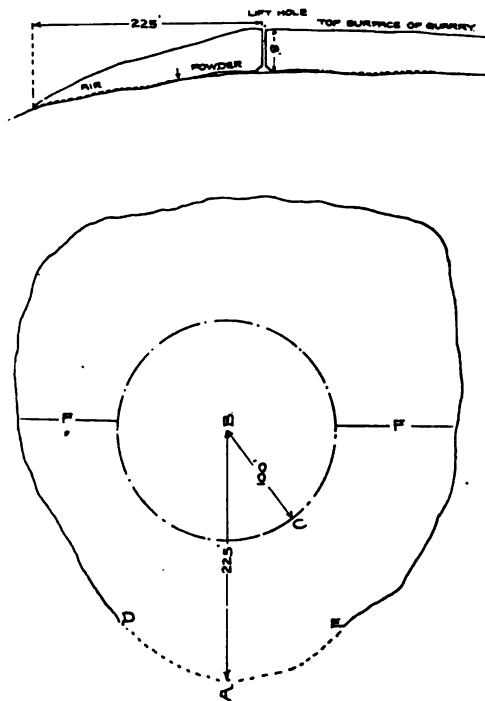


FIG. 2.—Diagrams illustrating method of cleaving granite by means of compressed air. *B*, lift or drill hole; *BC*, area cleared by powder; *AFF*, area cleaved by compressed air; *DE*, thin edge on down-hill side of quarry where air escaped.

means of a globe valve to an air pipe line from an air compressor. Compressed air at 70 to 80 pounds pressure is gradually admitted and the cleavage rapidly extended until it comes out upon the hillside in a thin edge as indicated by the cross-section, figure 2. A sheet of several acres in extent may be raised in this manner, affording a bed plane approximately horizontal, to which the quarrymen can work, thus securing stone of any required thickness. The first time compressed air was used a pressure of 80 pounds was admitted into the cavity

which had previously been extended to a distance of 100 feet from the lift-hole. The power of the air, however, was too great for the easily splitting stone and the cleavage turned abruptly to the surface. In the next hole, however, the compressed air was admitted very gradually and the stone could soon be heard cracking in all directions and in about half an hour the cleavage came to the surface of the hillside as a thin edge some 225 feet from the lift-hole. To extend the cleavage by means of powder for a hundred feet would require from 6 to 12 days, and with water from 3 to 5 hours, while with the compressed air the larger area was split in half an hour.

It is probable that this is the only quarry at the present time in which compressed air is used to split granite in this manner and it is a saving both of time and expense. By this and other economical methods of operation the North Carolina Granite Corporation is able to produce granite for building and paving purposes at a price comparing favorably with any quarry in the country. At the present time this is the largest and best equipped quarry in North Carolina and the market for its stone is constantly extending every month and wherever used, is giving good satisfaction. In Plate XXIII A is a general view of the power-house, cutting sheds and offices of the North Carolina Granite Corporation and in Plate XXIII B is an interior view of the cutting shed.

ALEXANDER COUNTY.

ROCKY-FACE MOUNTAIN GRANITE AREA.

Only one area of granitic rocks in this County is considered, namely, Rocky-Face Mountain, which is located about 6 miles northeast of Taylorsville, the county-seat, and about 4 miles north of Hiddenite. The so-called mountain is an elongated dome-shaped mass of granite-gneiss rising to an elevation of not less than 500 feet above the surrounding plain and measuring about 4 miles around the base. It is reported to contain something less than 1,000 acres. The slopes are not entirely uniform but are in all cases quite steep. Scattered clusters of cedar and pine have taken root in places over the rock-surface where a scant but sufficient soil is formed, and the bared rock is very generally covered with lichens. The ridge has an approximate northeast-southwest trend (see Fig. B, Pl. XXI).

The area is composed of a residual of biotite granite gneiss of light gray color and medium texture made up of alternating dark and light colored layers. The darker colored bands contain most of the black biotite and



A. GENERAL VIEW OF POWER HOUSE, CUTTING SHEDS, AND OFFICES OF THE NORTH CAROLINA GRANITE CORPORATION, MT. AIRY.



B. INTERIOR OF CUTTING SHED OF THE NORTH CAROLINA GRANITE CORPORATION.

the lighter colored ones consist chiefly of quartz and feldspar through which are distributed more or less scattered shreds of the biotite. Red garnet in small grains and crystals is a frequent mineral in the rock in places. The banding is of irregular thickness though generally averaging thin. A few narrow quartz veins, which are contorted and crushed from pressure-metamorphism, were observed penetrating the rock in places. Jointing is spaced at wide intervals and is not a conspicuous structural feature. The strike of the joint-planes observed was N. 30° E., and N. 80° E.

Microscopical Examination.—Microscopic study of a thin section of this rock shows a biotite granite-gneiss of medium texture. The microscope displays an interlocking aggregate of quartz and feldspar in which pronounced evidence of crushing and recrystallization from dynamic metamorphism is shown. The principal minerals are orthoclase, microcline, and micropertthitic intergrowths, with scant plagioclase, quartz and biotite with the usual accessories, none of which exert any special influence on the rock. Micropoikilitic structure is developed in the feldspar.

The rock is admirably suited for curbing and blocks for street purposes, and it should prove to be a valuable stone for this purpose. It has not been opened except to obtain a few stone for very local use. The rock very closely resembles in mode of occurrence, composition, texture and structure, the well-known contorted biotite granite-gneiss at Lithonia, DeKalb County, Georgia. The Georgia rock has had a very extensive market as a street stone and the closely similar Carolina rock should prove to be equally desirable.

A company recently organized in Salisbury, North Carolina, has purchased the entire area of granite-gneiss and it is expected that developments will be made shortly looking to extensive quarrying of the stone.

Between Taylorsville and the "Mountain," the country-rock is a schist and gneiss of the biotite type, varying in structure from thinly laminated to somewhat thickly banded, and which is considerably contorted and crushed. The rock is highly feldspathic in places assuming a distinct granite phase, and the schistosity is cut across by wide and narrow quartz veins.

WILKES AND ALLEGHANY COUNTIES.

THE STONE MOUNTAIN GRANITE AREA.

Numerous closely grouped large residuals of granite occur along the boundary between Wilkes and Alleghany counties, extending into both counties a few miles west of the middle western boundary of Surry

County. The areas lie partly in the northeastern portion of Wilkes County and partly in the contiguous southeastern portion of Alleghany County. One of the largest and most prominent of these residuals is known as Stone Mountain, located about 20 miles slightly east of north from Wilkesboro, the county-seat of Wilkes County; 5 miles a few degrees west of north from Trap Hill Post-Office, in the same County, and 18 miles northwest of Elkin, the nearest railroad point. The greater part of the granite area is in Wilkes County. Some of the other larger residuals in this area are locally known as Little Stone Mountain, Cedar Rock, Wolf Rock, and Beauty Falls Rock.

The granite residuals are oval or dome-shaped masses which vary in height from probably 100 to 600 feet, and in circumference at the base measure from probably 2 to 6 and more miles. There are some 8 or 10 of these residuals characterized by steep, nearly precipitous slopes rising from narrow intervening valleys. Both the tops and the slopes are usually covered with a scant veneer of soil, sufficient in many cases to maintain quite a growth of trees. In many instances, however, both the tops and the slopes are entirely bare, exposing the hard and firm though partially decayed rock.

STONE MOUNTAIN EXPOSURE.

Stone Mountain, the most prominent one of the granite residuals, is an oval-shaped mass of granite, 500 to 600 feet high and measuring 3 to 4 miles in circumference at the base. Its north, south, and west slopes are bare of vegetation and the top is practically so. The three slopes named are nearly vertical for an elevation of 300 to 400 feet, while the east slope is less steep, supporting a scant soil clad with trees and smaller forms of plant life (see Pl. XXV). The top of the mountain can only be gained from the east side.

A railroad line has been surveyed from a point near Elkin on the Wilkesboro branch of the Southern Railway to the base of the mountain, with some assurance of the line being built in the near future.

The rock is a light gray, nearly white, medium-grained, biotite granite of slightly coarser texture than the Mt. Airy granite in Surry County, which it closely resembles in color and other properties. Entirely fresh specimens of the rock could not be obtained as the granite had not been opened at any point. It is remarkably uniform throughout the whole area in both color and texture, though like the Mt. Airy granite, it shows a few segregated areas of black biotite, which become somewhat frequent in certain portions of the rock. Examination in the field of



EXTENSIVE BARE SURFACE EXPOSURES OF GRANITE OVER A RIDGE SLOPE WORKED BY THE NORTH CAROLINA GRANITE CORPORATION, $1\frac{1}{2}$ MILES NORTH OF MT. AIRY,
SURRY COUNTY.

the residuals indicates a similar granite of the same composition, color and texture for the entire area. Like the Mt. Airy granite, it is nearly free from joint-planes, not more than half a dozen joints being observed in the entire residual. These had a strike of N. 45° E., and N. 45° W.

All of the larger residuals of the granite in this area are apparently characterized by an almost entire absence of the visible jointed structure, while the same rock exposed in many places in the neighboring valleys is somewhat closely and conspicuously jointed, the planes having general northeast and northwest strikes. Local variation in the strike of the joint-planes amounting to a few degrees in different places is shown.

RÉSUMÉ OF THE GRANITES OF THE WESTERN PIEDMONT GNEISS BELT.

Massive granites are less abundantly distributed over the Western Piedmont Gneiss Belt than over some other parts of the State. One of the principal localities in the belt yielding rock of this type, which is being rapidly developed and which already constitutes certainly one of the largest quarrying centers in the State, is near Mt. Airy in Surry County. Extending along the boundary between Wilkes and Alleghany counties and covering an extended surface in both counties, are extensive unreduced residuals of granite not entirely unlike that quarried in the vicinity of Mt. Airy. The rock is lighter in color and coarser in texture than the Mt. Airy granite but it is a desirable stone for many purposes. No developments have yet been undertaken in the area because of its rather inaccessibility to the railroads. In the vicinity of Taylorsville and Hiddenite, Alexander County, is a large area of very desirable granite-gneiss which should prove to be an admirable stone for general street work and other purposes, especially in the form of blocks and curbing.

The granites of this belt are all biotite-bearing, usually of light color and of medium texture. With the exception of the Alexander County area which is a pronounced schistose granite-gneiss, the rocks of the other areas studied are massive in structure. Microscopically, they do not differ essentially from the granites of the more eastern areas of the State. The large amount of striated plagioclase, albite or oligoclase or both, is a noteworthy feature. No injurious minerals are observed, and, as a rule, the rocks possess marked strength and durability and are very desirable granites for certain grades of work.

The entire belt, as the name signifies, is one composed largely of gneisses of variable composition and texture, which in many places could be quarried and utilized to advantage in certain classes of work.

THE APPALACHIAN MOUNTAIN GRANITE AREA.

GENERAL DESCRIPTION.

In North Carolina, the Appalachian Mountain region includes an irregular mountainous area lying between the steep southeastern slope of the Blue Ridge and the northwestern slope of the Great Smoky mountains. The region has an approximate area of 6,000 square miles and an average elevation over all parts of its surface of 2,700 feet. Many of the peaks, however, rise to elevations of more than 5,000 and 6,000 feet, and Mt. Mitchell, the highest one, has an elevation of 6,711 feet.²⁷

The principal rock-types include gneisses, schists, slates, limestones, quartzites, and conglomerates, cut in places by basic eruptive rocks. Areas of granite and granite-gneisses are not uncommon.

The quarrying of the granitic rocks in the mountain region has been confined to a few areas of gneiss favorably located to obtain rock principally for road construction and to a less extent for rough work, such as street purposes and retaining walls in some of the local towns. Such openings have been made in and around Asheville, in Buncombe County, and recently in Henderson and McDowell counties.

In Madison County, North Carolina, and the contiguous part of Cocke County, Tennessee, a large area of dark colored, medium-textured, epidote-biotite-granite extends southwest from near Hot Springs which promises well, but as yet it has not been opened. The unique variety of granite known as unakite is associated with the above rock in the Hot Springs area, but so far as the examination of the Madison County area reveals, the true unakite probably does not occur in workable quantities (see Pls. III and VI).

BUNCOMBE COUNTY.²⁸

A number of quarries have been worked in the vicinity of Asheville to obtain rock principally for road purposes. Massive granites do not occur, and at every point where opened the rock is a pronounced schist or gneiss of the biotite type. Gradation is from typical mica-schist to quartz-schist through distinct fine-grained layers or bands of biotite gneiss of granitic composition. Outcrops are numerous along the roads leading from Asheville and along the steeper slopes of the ridges. The residual decay is extensive in places covering the rocks to some depth, in which the schistosity of the original fresh rock is entirely preserved. One

²⁷ Holmes, J. A., N. C. Geol. Survey, Bull. No. 8, 1899, p. 25.

²⁸ Keith, Arthur, Geologic Atlas of the United States, Cranberry Follo, North Carolina-Tennessee.



STONE MOUNTAIN, WILKES COUNTY, 18 MILES NORTHWEST OF ELKIN.

of the best exposures of decay seen in the County was in an excavation being made at the club-house near the entrance to the Battery Park grounds where the details of structure were entirely traced in the decay of the mica-schist.

With possibly several exceptions, the rock is wholly unsuited for any purpose save for macadam and ballast, and it is usually of inferior grade for even the former purpose. Some of the stone from the Howland quarry was used in the chimneys of the building in Overlook Park on Sunset Mountain. Crushers are located at each one of the quarries for grading and sizing the rock for the use made of it.

THE ASHEVILLE GNEISS AREA.

THE CITY QUARRY.

This quarry is located within the eastern limits of the city of Asheville. It was first opened about 12 years ago and has been continuously worked to the present time. The main opening is 215 feet in length, 100 feet wide and 80 feet deep. The rock is an irregularly banded fine-textured biotite-gneiss of dark gray color. Garnet is quite freely distributed through the rock in thin layers or lenses and as scattered disseminated small grains and crystals.

The layers are tilted at moderately steep angles rather closely cut by vertical joints in places, and the rock shows more or less effect of crushing from pressure-metamorphism. It has been used almost exclusively for street macadam, which is about the only use that can be made of it.

Microscopical Examination.—Under the microscope a thin section of the City quarry rock indicates a very fine-grained aggregate of quartz and feldspar, with a large percent of biotite now almost completely altered to deep reddish brown opaque masses filling the original places of the biotite. Some intergrown shreds of muscovite with biotite and scattered grains of black iron oxide occur. The parallel arrangement of the mica and its alteration products along definite lines, producing the schistose structure so characteristic of the rock, is very pronounced. The feldspar is largely orthoclase, which contains some inclusions and is more or less altered. Quartz predominates and the grains are often crowded with hair-like inclusions of rutile. Undulous extinction is marked in some of the quartz-feldspar grains.

THE HAMILTON QUARRY.

Between $\frac{1}{2}$ and $\frac{3}{4}$ of a mile south of the City quarry, an opening in the same rock has been worked in a very steep slope and the rock used for macadamizing a private road near Asheville. The rock is in every re-

spect similar to that worked at the City quarry described above, except that it is probably not quite so thinly schistose. Results of tests of this rock for road material are given on page 265.

THE BILTMORE QUARRY.

About 2 miles southeast of Asheville and some 500 paces away from and on the north side of the Swannanoa River, considerable stone has been quarried in a high nearly precipitous bluff facing the river. The rock is quite variable in structure and composition, but is the same as that described above within the city limits of Asheville. It was used for macadam on the roads in the vicinity of Asheville.

Microscopical Examination.—A thin section of the rock indicates, microscopically, a very fine-grained biotite gneiss in which the parallel arrangement of the minerals into bands is marked. The mineral grains complexly interlock and are composed largely of quartz, potash and plagioclase feldspars, and biotite, the latter mostly altered to a reddish brown opaque mass. Additional alteration of the biotite is into chlorite, a colorless mica, and some epidote. Much iron oxide, some pyrite, and an occasional zircon inclusion complete the list.

THE MONTFORD QUARRY.

This quarry is located near Riverside Park about 2 miles west of Asheville, immediately on the west side of the French Broad River. The opening is a large one, made in the high and steep bluff facing the river. It is a similar rock to that described above, and in 1903 and prior thereto it was quarried and crushed for use in macadamizing the roads in the vicinity of Asheville. The quarry is now owned by the Balfour Quarry Company and the principal use made of the stone is for railroad ballast. Results of tests of this rock for road material are given on page 265.

THE COUNTY QUARRY.

On the Sapphire road and on Beaverdam Creek, about 4 miles west of Asheville, a large opening has recently been worked in a moderately high and steep slope facing the stream. The rock consists principally of a highly quartzose gneiss of fine texture, and in places it contains much biotite. Veins of pegmatitic composition penetrate the rock in the quarry at irregular intervals. The stone was quarried by the county convicts and used for macadam on the roads.

Microscopical Examination.—Under the microscope a thin section indicates a rock of granitic composition with much biotite. Orthoclase,

microcline, and plagioclase make up the feldspathic constituent. The larger feldspar and quartz grains show much peripheral shattering in the fine-grained mosaic of the two minerals, largely quartz, filling the interspaces between the larger individuals of these minerals. Biotite is present in large amount, usually containing inclusions, and much altered to chlorite and iron oxide. More or less muscovite is associated with the biotite. Pyrite and garnet are sparingly distributed through the sections.

THE DUBOSE QUARRY.

About 6 miles northeast of Asheville, immediately on the east side of the Sapphire road, stone was being quarried in August 1903, by the county convicts for use in macadamizing the roads. The opening is a large one, approximating in size that of the city quarry. The rock is a mica-schist, grading in places into a true gneiss. It is quite feldspathic and contains thin, irregular lenses of garnet, which mineral is further disseminated through portions of the rock as single small grains and crystals.

THE HOWLAND QUARRY.

The Howland quarry is located about $2\frac{1}{2}$ miles a few degrees north of east of Asheville, just below Overlook Park, on Sunset Mountain, and it is immediately on the car-line. The rock varies from a mica-schist to a pronounced biotite gneiss of dark gray color and fine texture. Further variation is from thin to fairly coarse banding in structure, and with marked variation noted in texture. It is the same rock as that worked at the City quarry, displaying similar evidence of crushing and intersection by rather closely spaced vertical joints. Its principal use has been for ballast and road macadam, with a little of it used in the main building in Overlook Park on Sunset Mountain. Results of tests of this rock for road material are given on page 265.

Numerous other smaller openings have been made in favorable outcrops of the same rock in and near Asheville, and the stone has been used for a similar purpose as that described above under the several quarries.

SWAIN COUNTY.

THE BRYSON CITY GRANITE AREA.

About $1\frac{1}{2}$ to 2 miles west of Bryson City, in a cut on the Murphy-Asheville branch of the Southern Railway, occurs a medium coarse-textured light gray biotite granite-gneiss, exposed for a distance of nearly

half a mile. The granite is in contact with a mica-schist, the schistosity of which is cut across by the granite, plainly indicating the intrusive character of the latter rock into the schist. The schistosity of the granite-gneiss has a different strike from that of the schist.

The granite-gneiss is variable in structure from nearly massive to completely schistose. It is fairly uniform in color and is intersected at rather close intervals by joints, although moderate size blocks of the stone are possible by careful selection. The rock has not been worked, but should prove a desirable stone for ordinary uses, such as street work, etc.

Microscopical Examination.—A thin section of the rock from near Bryson City, in the Southern Railway cut, shows under the microscope a completely interlocking aggregate of potash feldspars and quartz with biotite and a very little striated plagioclase. Extensive shattering of the quartz and the feldspar from dynamic forces is abundantly manifested throughout the thin section in a finer-grained mosaic of these minerals, and by the characteristic strain shadows on the larger individuals. Dust-like inclusions, arranged in some cases along lines which may or may not be parallel and in other cases uniformly dotting all parts of the host, characterize both the quartz and the feldspar. Biotite is considerably altered to chlorite and epidote. The usual inclusions of apatite and zircon are noted.

MCDOWELL COUNTY.

THE MARION GNEISS AREA.

One-half mile southeast of Marion, the county-seat, about 300 feet above the valley bottom, is an exposure on the mountain side of a variable gneiss. It is situated on the north slope of the mountain, which is moderately steep though not too steep for a wagon road. The rock is a biotite augen-gneiss, of a light gray color, and usually of fine texture. It is closely intersected by vertical joints, spaced from a few inches to 5 and 7 feet apart, striking N. 45° E., and N. 45° W. The rock contains very many areas of segregated black biotite, some disseminated scattered grains of pyrite and is penetrated by a few narrow quartz veins and stringers.

Microscopical Examination.—Microscopically, a thin section of the rock shows a very fine-grained biotite-gneiss of granitic composition, in which the parallel arrangement of the minerals producing the schistose structure in the hand specimen is well developed. "Eyes" of potash feldspar, in which the micropoikilitic structure due to inclusions of

idiomorphic feldspar, are sparingly distributed through the fine-grained mosaic of interlocking quartz and feldspar grains. Quartz forms the most abundant mineral in the section. Both potash and plagioclase feldspars are present; the former in excess of the latter.

Biotite occurs in aggregates of fine shreds and single filaments, largely altered to an opaque reddish brown mass. There is considerable epidote, and some chlorite. Orientation of the biotite shreds in the direction of the longer diameters is pronounced. Strong pleochroism characterizes much of the epidote. Areas of micrographic intergrowths of quartz and feldspar are rather common, distributed about the borders of some of the feldspar "eyes." These larger feldspar individuals show much alteration into muscovite and kaolin.

A small amount of curbing has been quarried from the exposure and used on the streets in Marion. The town has purchased a crusher and is quarrying the rock for street purposes, which is practically the only use that can be made of it. Results of tests of this rock for road material are given on page 266.

HENDERSON COUNTY.

THE BALFOUR GRANITE AREA.

The principal quarry opened in Henderson County is located near Balfour station, several miles north of Hendersonville, the county-seat, known as the Balfour Quarry Company's quarry.

THE BALFOUR QUARRY COMPANY'S QUARRY.

This quarry is located three-fourths of a mile northeast of Balfour a station on the Spartanburg-Asheville branch of the Southern Railway. Two openings have been made about 75 paces apart, the larger one of which is about 100 feet by 50 feet, and worked to a depth not exceeding 25 feet in the deepest part. The smaller opening will measure about 60 feet by 30 feet and 6 feet deep. The openings are made in flat-surface exposures of the rock usually covered by an average depth of 5 feet of the decayed rock.

The rock is a light gray medium-grained, biotite augen-gneiss, and quite uniform in both color and texture. A few scattered areas of biotite segregations were observed in places in the rock. It is very thinly but perfectly schistose, the thin bands showing marked parallelism with each other. The biotite is not uniformly distributed through all portions of the rock but occurs in rounded aggregates of plates occupying distinct areas of knife-edge thickness along planes parallel to the schistosity,

squeezed out into more or less eye-like areas on the schistose planes. The "augen" of feldspar are quite variable in size. The jointing is spaced at wide intervals striking N. 40° W., and N. 45° E.

Microscopical Examination.—The microscope shows the rock to be a biotite granite-gneiss composed of the minerals quartz, orthoclase, microcline, micropertthitic intergrowths, plagioclase, light and dark micas, zircon, apatite, epidote, and chlorite. The large quartz and feldspar grains are completely enveloped in a fine-grained mosaic of these two minerals as a result from shattering by dynamic forces. The fine-grained mosaic makes up most of the section, the grains of which are complexly interlocking. Quartz-feldspar intergrowths in the form of micrographic structure are quite freely distributed through the section. The feldspar shows the usual alteration to muscovite and some kaolin. Biotite occurs in aggregates of fine shreds and single filaments of varying degrees of orientation, and it is much altered to chlorite, a colorless mica and epidote.

The rocks work well and nearly any size dimension stone can be quarried. Blocks of the stone measuring 4 by 8 by 10 feet are easily quarried. It has been used chiefly for railroad ballast and to some extent for road material. A rock crusher is operated at the quarry for sizing and grading the stone for the use made of it mentioned above (see p. 266).

TRANSYLVANIA, JACKSON AND MACON COUNTIES.

Beginning near Toxaway in the southwestern part of Transylvania County, crossing the extreme southern part of Jackson County and the southeastern part of Macon County to within 10 miles of Franklin, an extensive granite area is indicated principally in the form of scattered large bosses of residuals of granite, locally called mountains. Some of the principal ones of these bosses are Mt. Toxaway (Great Hogback Mountain), Little Hogback, Sheep Cliff, Double Top, Shortoff, Cow Rock, Whiteside Mountain, and Devil's Court House. The slopes and tops of many of the bosses of "mountains" are bare and the slopes are, as a rule, very steep and precipitous, though affording many excellent quarry sites.

The granite outcrops in many places in the little village of Highlands, and it is observed in many places along the Highlands-Franklin wagon-road, but the country rock for the most part is a varying schist, probably of sedimentary origin. Similar outcrops of granite are exposed along the Franklin-Andrews wagon-road and are traced to within a distance of 9 or 10 miles from Franklin.

As a rule, the rock is a fine-grain, light gray, biotite granite; usually quite massive though, in places, especially near the contacts with the country rock, it is more or less foliated or schistose. Jointing is fairly well developed though not conspicuous, and is widely spaced readily admitting of the quarrying of dimension stone. The color is generally quite uniform, varying from light to medium dark gray.

Nowhere over the area has the rock been systematically quarried, but openings have been made here and there to obtain granite for local use, such as near Toxaway Inn, at Highlands, and at Whiteside Mountain. The area is a large one the limits of which have not been traced out though containing many square miles, and it would prove to be of more or less importance were the transportation facilities favorable. It is doubtful whether the rock could be used for the best grades of building and monumental stock, but it would undoubtedly prove to be a desirable stone for use in curbing, piers, blocks and all classes of street work, and foundations.

MADISON COUNTY.

THE HOT SPRINGS GRANITE AREA.

Beginning about 5 miles southwest of Hot Springs and extending in a general southwest direction along the Tennessee-North Carolina boundary, in Madison County, North Carolina, and Cocke and Sevier counties, Tennessee, is an extensive area of granite, lying mostly in North Carolina so far as exploited. The exact limits of the area were not traced by the writer, but it was traversed for a distance of approximately 6 by 7 miles. Keith^{*} has recently defined the limits of this area in the Asheville folio, which he maps as quite irregular but extensive.

The area forms a part of the rough mountainous region of western North Carolina and eastern Tennessee and it is difficult of access. The elevations above sea-level range between 2,500 and 4,500 feet. The nearest railroad point is Hot Springs, a station on the Salisbury-Knoxville branch of the Southern Railway. Outlet from the area to the railroad is over very rough mountain trails and roads, the winding, circuitous routes of which make it difficult to reach the nearest railroad point from the center of the area in less than 10 miles.

Two types of granite are found in the area, both of which contain epidote as a characterizing mineral. The main type of the rock is a dark pink green epidote-biotite-granite of coarse texture and somewhat schis-

^{*}Geologic Atlas of the United States, Asheville Folio, North Carolina-Tennessee, U. S. Geol. Survey, 1904.

tose structure. It varies from a typical schistose granite in which quartz is present in the usual amount to a nearly quartzless rock of the same color and texture—a variation from granite to syenite. Both the color and the texture are quite uniform over the area. Outcrops are rather numerous along the streams and the ridge-slopes but they have nowhere been opened. Jointing seems not to be conspicuously developed in any of the outcrops examined.

UNAKITE.

The second type of granite occurring in this area is the unique and beautiful variety of granite known as unakite, composed of yellow-green epidote, dull pink or red feldspar, and quartz. So far as could be determined from the few exposures of the unakite seen, its occurrence is probably in the form of narrow veins penetrating the epidote-biotite-granite described above. The unakite where observed is not uniform in color and composition but shows pronounced gradations into a highly feldspathic rock of pink color on the one hand and an epidote rock of a yellow-green color on the other. The several phases of the rock here described usually occur in the same "vein," the unakite proper occupying, as a rule, the middle portion and grading toward the sides, next to the enclosing granite, into either a feldspathic or epidotic rock or both. The typical unakite portions of the "veins" show a coarse massive rock of even texture and of a light pink and green color.

The exposure best showing the relations between the unakite and the unakite-bearing rock seen was along Roaring Fork, a short distance above its entrance into Meadow Fork. At this point the vein character of the unakite seemed apparent. The other exposures of the unakite examined were almost entirely covered by decay obscuring any contacts between it and the enclosing rock, and therefore revealed little or nothing of the real relations of the two rocks. It is quite possible that careful detailed study of the area will prove unakite to be in part at least a possible phase of the unakite-bearing rock; but it is not found over the area traversed in workable quantities and cannot be regarded as of serious commercial importance. This statement applies strictly to the area in question and workable masses of the epidote granite may or may not exist in other parts of western North Carolina and the contiguous part of Tennessee.

Microscopical Examination.—Under the microscope the unakite-bearing granite is composed of the usual granitic minerals, such as orthoclase and microcline in nearly equal proportions, a little plagioclase, quartz,

occasional biotite, zircon, apatite, rutile, magnetite, and a few small grains of pyrite. The secondary minerals are a colorless and a green mica, epidote, chlorite and kaolin.

The epidote is clearly an alteration product derived from the interaction of the ferro-magnesian constituent and the feldspar. It occurs in the form of minute microscopic granules, thickly crowded together in large and small areas in the feldspar, next to the biotite when the latter is present. The quartz contains innumerable long lines of thread-like inclusions of rutile, broken into very many minute segments but always perfectly aligned. In addition to the epidote the feldspar alteration into a colorless mica almost completely obscures, in a few instances, the original mineral.

Some peripheral shattering is manifested in the small interstitial areas and the narrow border zones of a fine-grained mosaic. The effect of dynamic forces is further shown in strain shadows and lines of fracture in the quartz and feldspar. In some cases the larger feldspar grains are much fractured and the lines are filled with another mineral; at other times alteration has progressed along these lines and patches of deep green mica is developed in them.

A thin section of the unakite under the microscope shows a moderately coarse-grained granite composed of orthoclase, quartz and epidote with titaniferous iron oxide largely altered to leucoxene, rutile inclusions, and secondary muscovite. The quartz and feldspar individuals are considerably fractured, and they show additional strain shadows with some peripheral shattering, indicative of intense dynamic deformation.

The epidote in the unakite from this area shows from its mode of occurrence and association in the thin sections that it is entirely a secondary or derived mineral and not primary. It occurs in large masses composed of minute microscopic granules, replacing the entire feldspar individuals in many instances; and as continuous and irregular disconnected bands and areas of both large and small size, following the fractures in both the feldspar and the quartz, but more extensively developed in the feldspar. The development of epidote along the breakage lines is continuously traced in many cases from the larger areas or masses replacing the entire feldspar individuals across or into contiguous feldspars. In still other cases the feldspar shows scattered granules of epidote over its surface. All gradations between these two extremes of epidotization appear. Hardly any of the feldspar in the sections examined was entirely free from some epidotization.

Besides epidote, the other mineral matter consists mostly of quartz,

which sometimes fills the cracks in the larger quartz and feldspar grains made by the fracturing. Some of the less epidotized feldspar shows additional alteration into a colorless mica and some kaolin. No plagioclase and no ferro-magnesian minerals were recognized in any of the sections of the unakite.

GRANITE IN OTHER COUNTIES OF THE MOUNTAIN REGION.

Previous work by the North Carolina Survey⁴⁰ on the minerals and the ore-deposits of the mountain region indicates that similar areas of granite rock to some of those described in this report, principally gneisses, occur in other of the mountain counties of the State. Many of these areas upon investigation will doubtless prove to be of some economic importance and value. Both mica and hornblende varieties of the rock are reported.

Recent work in the State on the Cranberry folio by Keith⁴¹ of the U. S. Geological Survey shows the occurrence of somewhat extensive areas of granites and derived granite-gneisses in parts of Mitchell, Caldwell, Watauga and Ashe counties. According to Keith, these rocks are considerably metamorphosed from dynamic forces and are now largely schistose in structure. Both the even-granular and the porphyritic facies are developed. Variation in color is from nearly white, through different shades of gray to deep reddish pink; and in texture from medium fine, even-granular to coarse porphyritic. The principal minerals are quartz, potash and plagioclase feldspars, biotite and muscovite with the usual accessories. Much epidote and chlorite are present at times as secondary minerals derived from the alteration of the feldspars and micas. Mr. Keith assigns these rocks, which include the Carolina gneiss, Roan gneiss, Cranberry granite, Blowing Rock gneiss and the Beech granite, to the Archean. He regards much of the rock over the area as suitable for building and ornamental stone and states that the Roan gneiss and Cranberry granite have already been utilized for chimneys, foundations and bridge piers. Dimension stone is obtainable of uniform color and texture, and some of it is described as taking "a handsome and durable polish." In many places over the area large and extensive exposures of the rock occur affording desirable locations for quarries. The stone withstands weathering quite well as indicated in the natural exposures.

⁴⁰ See the various reports on these subjects issued by the N. C. Geol. Survey.

⁴¹ Keith, Arthur, Geological Atlas of the United States, Cranberry Folio, North Carolina-Tennessee, U. S. Geol. Survey, 1903, pp. 2-8.

In addition to the granitic rocks described in this area, volcanic rocks of both acid and basic types are described, some of which are referred to as of commercial value.

RÉSUMÉ OF THE GRANITES OF THE MOUNTAIN REGION.

Granites, both massive and schistose in structure, are quite widely distributed over parts of the mountain region of the State. More often the granites are schistose in structure and they are usually biotite-bearing. Additional large areas of gneiss occur of variable composition and texture, well illustrated in the vicinity of Asheville, Buncombe County, where many openings have been made and much of the stone has been quarried for local use, principally, as macadam for the roads and streets, and to some extent as ballast. Gneisses of both sedimentary and igneous origin occur. In addition to the acid rocks, massive and schistose types of basic igneous rocks are met with in places over the region, and in some instances they are found in large enough quantity and of such character as to make them of value for certain uses.

To the southwest of Hot Springs, in Madison County, North Carolina, and Cocke County, Tennessee, is an extensive area of biotite-epidote granite of pleasing dark green and mixed yellow color, which in connection with its other good qualities should prove to be of economic importance. The so-called unakite found in association with this rock does not exist in workable quantities and it has only scientific interest. The area is rather inaccessible and could only be developed at considerable cost.

No quarrying of a systematic kind has yet been undertaken at any point in the mountain region, but numerous small openings have been made in exposures of the rock in many places, located usually very near some town or railroad, and the stone has been used entirely for local purposes. Some of the granites of the region are accessible and can be quarried, while other areas of the rock could only be developed at an increased cost of production because, principally, of inaccessibility to transportation facilities.

CHAPTER III.

DIKES AND VEINS PENETRATING THE CRYSTALLINE ROCKS OF NORTH CAROLINA.

Intersecting materials of several different types, indicating marked variation in composition and texture, have wide distribution over the crystalline area of the State. These include, beginning with the most acid, true quartz veins, pegmatite, aplite and granite dikes, of normal composition and texture; and abundant dikes of basic igneous rocks of which diabase and diorite are perhaps the commonest types. Textural differences among these rocks are those usually characteristic of the rock types enumerated.

In width the dikes and veins may vary from several inches to several hundred yards with marked variation indicated on the strike. All the types named have been observed penetrating the granites as well as the other more important and extensive rocks forming the crystalline complex. The most recent rocks in the State yet noted intersected by the dikes are the triassic sandstones.

A list of those dikes of basic composition whose trend has been observed is given below in tabulated form. The list is by no means complete as it includes only the more important basic dikes in the areas traversed during the past field season. These are described elsewhere in this report separately by counties in connection with the granite. Fuller petrographic description and lithologic relations of these rocks will probably be published later when more detailed studies of the crystalline rocks of the State are made.

It will be observed from the diagram below that of the total number of dikes recorded 73, more than half, 44, lie in the northwest quadrant. Of the remaining ones 15 lie in the northeast quadrant; 13 have a north-south strike, and one has an east-west strike. The variation in the northwest quadrant is from N. 10° W. to N. 50°-60° W.; and in the northeast quadrant from N. 20° E. to N. 45°-50° E.

Comparing these observations with similar and more detailed ones by Shaler on Cape Ann, Massachusetts, we find the principal direction

or the quadrant containing the largest number of dikes to be the same for the two widely separated areas, namely, the northwest quadrant. Of the 361 dikes observed on the Cape, Professor Shaler records 266 that lie in the quadrant between northwest and north.¹

In the case of the North Carolina dikes here recorded, composition seems not to have been a guiding principle as to cutting direction, for it is observed that those of the diabase type, which are the most common, cut in several directions.

JOINT STRUCTURES.

The recorded observations on jointed structure in this report were almost entirely limited to the quarries, since the prevailing decay of the rock did not permit, as a rule, of sufficiently accurate results in observing the jointing in the natural exposures of the rocks. There are, however, some exceptions to this statement to be noted. In the large exposures of granite the rock is usually hard and firm, sometimes nearly fresh though more or less discolored from partial weathering, in which the joint-planes, when sufficiently developed, could be as accurately observed as in the quarries. Such an example is furnished in the granite ridge known as Dunns Mountain occurring 4 to 5 miles east and southeast of Salisbury, in Rowan County. Numerous openings are made at irregular intervals on the ridge, but the inter-quarry areas are sometimes free from accumulated residual decay and the rock surface is hard and firm, in which the jointing is well developed and can be accurately measured.

The observations here recorded extend over the entire State where granites occur, hence the number of observations is fairly large. The examination of the list reveals two principal sets of jointing, namely, in the northeast and northwest quadrants, respectively, with quite frequent jointing in places in two other directions, east-west and north-south. In the northwest quadrant the direction of jointing varies between N. 10° W. and N. 80° W., with precisely the same extremes in the strike noted for the northeast quadrant. It will be further noted from the tabulated list of the joints given below that the greatest number has its planes in the northwest quadrant. Of the minor sets of joints striking north-south and east-west, nearly equal distribution obtains for

¹ Shaler, N. S., *The Geology of Cape Ann, Mass.*, 9th Ann. Rept. U. S. Geol. Survey, 1887-1888 (1889), p. 580.

the two directions, though the north-south direction has several more than the east-west ones.

SLICKENSIDES.

In most of the quarries where the jointed structure is at all well developed the sides of the joints show smooth, more or less polished and striated surfaces, indicating considerable relative movement in the rocks since the formation of the joints. The striæ are usually developed in a thin coating of a dark yellow to yellowish green mineral, which probably in most cases is damourite, sometimes epidote, or a mixture of the two, an alteration product derived from certain original minerals in the fresh granite, principally mica, and has resulted from the rubbing together of the two sides along the plane.

DIKES OF BASIC COMPOSITION INTERSECTING THE GRANITES.

Dikes of basic igneous rocks, principally diabase, have been observed penetrating the granites in almost every important area of these rocks in the State. Of the total number of dikes recorded, the largest number of them has been noted from surface exposures of the rocks, which are invariably more or less completely decayed, obscuring any former trace of jointed structure in the enclosing rock. Quite a number of the quarries, however, exposing fresh rock have afforded splendid opportunity for noting the relations of the dikes to the structural features of the granite. Without exception almost, in those cases where dikes of basic igneous rocks were observed penetrating the granites in the quarries, the dike follows persistently one of the major sets of jointing. In a number of quarries, a half dozen or more dikes in parallel position penetrate the granite within the limits of the quarry opening, the largest quarry opening of which will not exceed 300 feet.

The widest of these dikes exposed in the granite openings will not exceed 50 feet and they are frequently less than 6 feet in width. In those openings noted in the State exposing a number of the dikes, the interval at which the dikes cut the granite varies greatly. Within a zone of 12 to 15 feet, two or more dikes may occur, always parallel and at all times coincident with the jointing in that direction. More often, however, the intervals at which the dikes intersect the granite are considerably greater. The dip of the dikes is vertical or only varies a few degrees from vertical, a feature likewise characteristic of the jointing. Figs. A and B of Pl. V show the position of the dikes in the granite in one of the quarries.

The following table makes clear the relationship between the strike of the dikes and that of the jointing:

Locality.	County.	Strike of Dikes.	Strike of Joints.
Charlotte City Quarry.....	Mecklenburg.	N. 40° E.	N. 40° E., N. 35-50° W.
One and a quarter miles north of Greensboro	Gulford.	N. 20° E.	N. 20° E., N. 50° E., N. 20° W.
A half mile southeast of Jamestown..	"	N. 40° W.	N. 40° W., N. 20° E.
Half a mile east of Davidson.....	Mecklenburg.	N. 15°-20° W.	N. 20° W., N. 70° E.
Three-quarters of a mile southwest of Rolesville	Wake.	N. 20° E.	N. 20° E., E.-W.
One-quarter of a mile north of Liles- ville	Anson.	N. 20° W.	N. 20° W., N. 70° E., N.-S.

ACID DIKES AND VEINS PENETRATING THE GRANITES.

Unlike the dikes of basic igneous rocks intersecting the granites, those of acid composition do not conform to any definite direction in trend nor do they appear to be in any way related to the jointing. On the contrary, they are found intersecting the granite in directions coincident with nearly all points of the compass. They are characterized by equally as great variation in width, composition and texture. Under this class of intersecting material are included pegmatite, quartz, normal granite dikes and occasional aplite.

Pegmatites.—Pegmatitic veins and dikes are found intersecting the granite in a majority of the quarries in the State. They are so numerous in portions of some of the quarries that dimension stone is difficult to obtain. This is especially true of the Raleigh city quarries of biotite granite-gneiss where hardly a block of any size can be quarried that is entirely free from the quartz-feldspar veins, a circumstance strikingly shown in the State Capitol building in Raleigh built of this stone. In some of the quarries pegmatites are only sparingly developed and in others still they are entirely absent.

Where observed, they are characterized by the usual coarse-textured pegmatitic structure, composed principally of coarse crystallizations of feldspar and quartz with subordinate stout platy black biotite. The feldspars are both pink and white and are highly lustrous with good cleavage development, and twinning after the Carlsbad law is frequent. Feldspar is the most abundant constituent, the quartz frequently diminishing to very subordinate amount. Quartz is usually of the light and the dark smoky varieties which, with the pronounced vitreous luster, contrasts sharply with the feldspar. Biotite is usually present in large, stout platy forms, at times irregularly distributed between the feldspar and quartz, at others distributed along a central axis in the vein or dike. Muscovite has been observed in the pegmatite bodies only occasionally,

and tourmaline, garnet and the rarer minerals sometimes associated with pegmatite are strikingly absent.

The pegmatites are very extensive in some cases, though usually narrow, apparently deep-seated and of aqueo-igneous origin. Others are limited in extent, surrounded entirely by the granite, denoting in such cases probably true veins of segregation. In the Raleigh City quarry where the only true aplite has been observed, the aplite and pegmatite are associated as banded aplite-pegmatite. As a class the pegmatites are irregular in outline conforming to no definite or fixed direction but they cut the granite at random and at all angles.

In the Raleigh City quarry, the Carrigan quarry, 3 miles northeast of Mooresville, in Iredell County, and the Walker quarry, $1\frac{1}{2}$ miles south-east of Ridge Summit station, in Guilford County, the pegmatites are frequently noted intersecting each other in a faulted condition of several inches displacement.

Aplite.—Aplite dikes have been observed at only one locality in the State, namely, in the City quarry at Raleigh, where they number less than half a dozen in all. They do not exceed 6 inches in width, usually not more than 2 inches, and in several instances they are in contact with pegmatite on one side and with the enclosing granite on the other. Megascopically, the aplite is very light in color, composed of a fine-grained crystallization of quartz and feldspar, through which are irregularly distributed subordinate very small flecks of black biotite.

Microscopically, the aplite is strikingly similar in mineral composition to the enclosing granite, except that the former is very fine grained and differs only in the former being much finer in texture and containing a much smaller proportion of biotite and plagioclase feldspar. The mineral composition of the rock would place it with the potash aplites.

Granite Dikes.—True granite dikes of normal composition and of fine texture are very numerous in certain areas of the State. At only a few localities, however, have they been observed penetrating the granite masses. In several of the granite quarries near Greystone, in Vance County, and in a flat-surface exposure of porphyritic granite half a mile north of Mount Mourne, Iredell County, fine-textured biotite granite dikes have been observed penetrating the granite. The dikes are dark gray in color containing much uniformly distributed black biotite in minute shreds, with quartz and feldspar. As a rule, they do not exceed more than a few inches in width, 4 to 12, and are definitely oriented.

At Belmont Springs, $1\frac{1}{2}$ miles east of Charlotte, Mecklenburg County, the granite is cut by a dike of quartz porphyry spotted with pencils of

manganese and iron oxide, from which it has derived the name of leopardite. A description of the leopardite is given on pages 70-74 of this report.

In the main granite belt of the State crossing in a northeast-southwest direction the middle Piedmont region (maps, Pls. III and VI), granite dikes are quite numerous over many parts of the area. The rock of this belt is principally a complex of granite and diorite.

Numerous small irregular dikes of a fine-textured pink granite containing but little mica cut the dioritic rock at many localities throughout the belt. The dikes are usually irregular in outline and, as a rule, they vary only a few degrees from the vertical. They are always of fine texture and vary from a few inches to several feet in width (see Pl. V, B). Feldspar of light to deep pink in color invariably predominates. The mica is in subordinate amount and is usually of light color.

In no case were the dikes continuously traced from the rocks which they penetrated to the larger granite masses, nor do they resemble in all cases the rock of the main granite stocks, but they show less mica and are invariably finer grained. In most cases not much doubt exists, however, of their real significance. Mainly for the reason that these dikes are almost always more numerous near the granite-diorite contacts than at some distance away from them, they must be regarded as probable apophyses from the main granite masses. No openings have been made at any point exposing the fresh rock, but in all cases the exposures are in the partially or nearly completed decay of the rocks made by cuts along the railroads and the public highways.

The dikes are not confined exclusively to the dioritic rocks but penetrate others as well, such as the so-called slates around Salisbury along the roads leading east and west from the town.

The principal localities where the granite dikes have been noted are: Northeast of Concord in Cabarrus County, for several miles along the Concord-China Grove road; near Concord and on the east along the Mt. Pleasant road; along the east and west roads leading out of Salisbury a short distance from the town; 5 miles west of Barber Junction in the vicinity of Elmwood, Iredell County; in the cuts of the Southern Railway in the vicinity of Lexington, Davidson County; and again to the north and south of High Point, Guilford County, in the railroad cuts.

Quartz Veins.—Quartz veins of small dimensions cut the granite in a number of the quarries, usually in those quarries where pegmatitic intrusions are strongly developed. The two sets of intersecting material are more or less closely associated. The quartz composing the veins is

of the usual clear vitreous kind generally found filling such veins. They are not numerous in any of the openings, and, as a rule, they do not measure more than a few inches across.

Quartz veins of large dimensions are numerous over the crystalline area of the State. They are readily traced over the surface for considerable distances in many cases by the partially disintegrated outcrops and the abundant fragments which litter the surface. In cross-section they vary from 25 feet to several hundred yards. In some localities the veins are sufficiently large to render the quartz of some local value in road construction. In other localities these veins form true fissure veins, are metalliferous, and mark many of the most important gold and copper mines in North Carolina.

RELATIONSHIP BETWEEN THE JOINTING AND THE DIKES.

The statements here made apply more particularly to the dikes of basic composition. The observations on these structures seem comprehensive enough to warrant some general statements which may be more closely followed in future work in the State to ascertain whether a fixed relationship does obtain. Referring to the tables recording the strike of the joints and the dikes, a marked parallelism is observed in certain directions between the joints and the dikes. The planes of most of the joints are in the northeast and northwest quadrants. Likewise the strikes of most of the dikes are in the same quadrants. Moreover, in nearly every quarry where basic dikes are exposed, the strike of the dikes and that of the joints for a given direction is coincident, apparently indicating that for those cases, at least, the jointing has exercised some influence on the cutting direction of the dike. Not only is this true for the dikes penetrating the granite in various quarries but it is also true of the Triassic sandstone belt where the same relation between joints and dikes obtains. Whether this will apply in general to the dikes beyond the limits of the fresh rock exposures it is not possible to say though presumably it does, since the jointing is entirely obscured by the deep residual decay covering the fresh rock.

For reasons stated below the basic dikes of the State, so far as they have been observed, do not all belong to the same period of intrusion but are to be referred to different ages. The observations recorded denoting coincidence in the direction of dike and that of joint, include both the massive, unaltered igneous intrusive and the perfectly schistose more or less altered basic dike. If these observations are correct, clearly the jointing in the granites antedates the intrusion of the basic rocks forming the dikes.

AGE RELATIONS OF THE BASIC DIKES.

Over many parts of the crystalline area where basic dikes are noted penetrating the rocks, strongly contrasted structural differences in the dike rocks obtain. Many of them are entirely massive and unaltered, bearing no evidence of pressure metamorphism; while a large number of them are more or less perfectly schistose and are otherwise mashed and closely jointed, which caused them to separate into small rhomboidal blocks. The ferro-magnesian constituent in the latter is usually much altered. Both classes of dikes often intersect original massive igneous rocks that are now more or less schistose in structure, induced by pressure metamorphism.

These facts afford a strong basis for regarding the basic dike rocks to be of different periods of intrusion and therefore of different age. The massive dikes intersecting the more or less schistose igneous rocks must post-date the period of disturbance inducing the schistose structure in the enclosing rock; and likewise the schistose dikes were intruded at an earlier period and prior to the metamorphism of the enclosing rocks, for the field evidence indicates that the schistose structure in the two rocks is the result of the same forces.

Until the age of the granites or other enclosing rocks is definitely fixed, the exact age of the more schistose dikes must remain conjectural. These must antedate the period of pressure-metamorphism affecting the enclosing rocks for both dike and enclosing rock are similarly affected.

The Triassic sandstone occupying the eastern marginal position of the Piedmont plateau region in the State are, as in the case of the granites, cut by typical massive diabase dikes. These dikes conform to an approximate northeast direction. Nowhere in the State have the dikes been observed to intersect or penetrate rocks younger than the Triassic sandstones. Their age is accordingly definitely fixed as late Triassic or Jurassic, and they are correlated with the flows of the same composition in New Jersey, New York, and the Connecticut Valley region, and with similar dikes in Virginia and Georgia to the north and south of the Carolina area. The dikes of the Carolina sandstone belt are traced into the neighboring crystalline rocks of the plateau, where they have wide distribution over the entire crystalline area of the State. Beyond the limits of the sandstone belt in the crystalline areas penetrated by dikes of basic igneous rocks, close similarity in texture, structure and composition of the massive dikes to those of the sandstones, and their relations to the enclosing crystalline rocks make it reasonably certain that they are of the same age as those intersecting the Triassic sandstones.

TABLE SHOWING THE DISTRIBUTION AND STRIKE OF THE DIKES OF BASIC ERUPTIVE ROCKS OF THE MAIN GRANITE BELT OF THE PIEDMONT PLATEAU REGION.

Locality.	County.	Strike.	Width in ft.
Charlotte City quarry; a number of parallel dikes.....	Mecklenburg.	N. 40° E.	3 +
East limits of Charlotte; two parallel dikes.....	"	NE.-SW.	25-100
East limits of Charlotte (Belmont Springs).....	"	NW.-SE.	100 +
Four miles east of Charlotte.....	"	....	6-25
Eight and a half miles northeast of Charlotte.....	"	N. 10° W.	200 +
Five miles northeast of Charlotte.....	"	NW.-SE.	50 +
Nine miles north of Charlotte (2 miles north of Newell)...	"	N. 20° W.	150 +
Ten miles north of Charlotte (3 miles north of Newell)...	"	N. 20° W.	...
One mile west of Charlotte; two parallel dikes.....	"	N. 20° E.	12
One-half mile east of Davidson.....	"	N. 15° W.	10 +
Two and a half miles east of Davidson.....	"	NE.-SW.	25 +
One and a quarter miles southwest of Davidson.....	"	NW.-SE.	100 +
East limits of Concord.....	Cabarrus.	N. 30° E.	25 ±
One mile east of Concord.....	"	NW.-SE.	100 +
One mile north of Summit Siding.....	"	NW.-SE.	...
Six miles southwest of Concord (Rocky River).....	"	NW.-SE.	50 +
Three miles east of Salisbury.....	Rowan.	N. 20° W.	...
Three miles south of Faith village.....	"	N. 30° W.	500 +
Four miles southwest of Faith village.....	"	N.-S.	4 +
Seven miles northwest of Salisbury.....	"	NW.-SE.	15 ±
Eight miles northwest of Salisbury.....	"	N.-S.	25 ±
Nine miles northwest of Salisbury.....	"	N.-S.	6 ±
One and a half miles south of Cooleemee Cotton Mills...	"	E.-W.	25 ±
Two miles south of Cooleemee Cotton Mills.....	"	NW.-SE.	9 ±
One mile northwest of Mooresville.....	Iredell.	NW.-SE.	6 ±
Three-quarters of a mile west of Oaks Ferry.....	Davie.	N. 20°-30° E.	100
One mile west of Oaks Ferry.....	"	N. 30° E.	8
One and a quarter miles west of Oaks Ferry.....	"	NE.-SW.	100 ±
Three hundred yards north of the Hairston residence.....	"	NE.-SW.	100 ±
Three hundred yards north of the Hairston residence.....	"	NE.-SW.	100 ±
One-half mile north of the Hairston residence.....	"	NE.-SW.	...
Five miles south of Winston-Salem.....	Forsyth.	N.-S.	35 ±
Northwest limits of Salem.....	"	N. 20° E.	200 +
One and a half miles east of Winston-Salem.....	"	N. 5°-10° W.	25 ±
Three-quarters of a mile southwest of Bethania.....	"	N. 20° E.	200-500
One mile west of Greensboro.....	Guilford.	NE.-SW.	100 +
One mile west of Greensboro.....	"	NE.-SW.	50 +
Two and a half miles southwest of Greensboro.....	"	NW.-SE.	...
Three miles east of Greensboro.....	"	NW.-SE.	25 +
One and a quarter miles north of Greensboro.....	"	N. 20° E.	8 +
One mile southeast of Jamestown; several parallel dikes close together	"	N. 20° E.	1-15
Nine miles northeast of Greensboro; several parallel dikes.	"	NE.-SW.	25-100
Ten a half miles northeast of Greensboro.....	"	N.-S.	200 ±
Three and three-quarter miles northeast of Greensboro....	"	N.-S.	15
Nine miles northeast of Greensboro.....	"	NE.-SW.	2
One-half mile southeast of Jamestown.....	"	N. 40-50° W.	...
Near depot at Jamestown.....	"	NE.-SW.	25 +
Total number of dikes with strike N. 5°-50° + W.....			20
" " " N. 20°-40° + E.			21
" " " N.-S.			6
" " " E.-W.			1

TABLE SHOWING THE STRIKE OF THE JOINTS PENETRATING THE GRANITES OF THE MAIN GRANITE BELT OF THE PIEDMONT PLATEAU REGION.

Locality.	County.	Strike of Joints.		
City of Charlotte.....	Mecklenburg.	N. 40° E.	N. 35°-50° W.	
Limits of Charlotte.....	"		N. 10° W., N. 60° W.	
Limits of Charlotte.....	"		N. 40° W.	
East of Davidson.....	"	N. 70° E.	N. 20° W.	
Three-quarter miles southwest of son	"	N. 20° E.	N. 45° W.	N.-S., E.-W.
East of Gastonia.....	Gaston.	N. 40°-60° E.	N. 60°-70° W.	N.-S., E.-W.
Three-quarter miles north of Gastonia	"	N. 30° E.	N. 60°-70° W.	N.-S.
Three-quarters northwest of Belmont.....	"		N. 20° W.	
Limits of Concord.....	Cabarrus.		N. 60° W.	
East limits of Concord.....	"			N.-S., E.-W.
Three-quarters southwest of Concord.....	"	N. 40° E.	N. 40° W.	
Over, Fires' Mill.....	"	N. 70° E.	N. 40° W.	
East, north side of Stokes Ferry Road.	Rowan.	N. 60° E.	N. 25° W.	N.-S., E.-W.
East of Dunn's Mt., four miles east	"	N. 70° E., N. 20° E.		
Salisbury	"	N. 60° E., N. 25° E.		E.-W.
Quarries, five miles southeast of	"			
Salisbury	"	N. 15°-20° E.	N. 30°-40° W.	
Granite Company's quarries, five miles	"	N. 80° E., N. 25° E.	N. 70° W.	
East of Salisbury.....		N. 65° E., N. 20° E.	N. 50° W.	
		N. 45° E., N. 15° E.	N. 45° W.	
		N. 40° E., N. 10° E.	N. 40° W.	
		N. 35° E.		
Bed Granite Company's quarries,	"	N. 80° E.	N. 50° W.	N.-S., E.-W.
Faith village.....		N. 40° E.	N. 40° W.	N.-S.
Mt., nine miles southwest of Salis-		N. 10° E.	N. 30° W.	
Three-quarters southwest of Faith.....	"	N. 30° E.	N. 70° W.	
East limits of Woodleaf.....	"	N. 60° E., N. 20° E.		E.-W.
Three-quarters northwest of Mooresville.....	Iredell.		N. 65° W.	
Three-quarters half miles southwest of Mooresville.	"		N. 45° W.	N.-S., E.-W.
Three-quarters northeast of Mooresville.....	"	N. 65° E.		N.-S.
Three-quarters miles north of Mooresville.....	"	N. 70° E.		N.-S.
East of Cotton Mills	Davie.	N. 45° E.	N. 45° W.	N.-S.
Three-quarters south of Winston.....	Forsyth.	N. 50° E.	N. 45° W.	
Three-quarters southeast of Winston.....	"		N. 80° W.	
East limits of Greensboro.....	Guilford.		N. 40° W.	N.-S., E.-W.
Three-quarters a quarter miles north of Greensboro.	"	N. 20° E.	N. 20° W.	
Three-quarters a half miles northeast of Greensboro.	"	N. 60° E.		
Three-quarters ter mile south of Summerfield.....	"	N. 10° E., N. 70° E.		
Three-quarters mile southeast of Jamestown.....	"	N. 20° E.	N. 40° W.	
Three-quarters a half miles northwest of Burling-	Alamance.	N. 10° E.	N. 20°-30° W.	
Three-quarters ace Mtn., six miles northeast of Tay-	Alexander.	N. 80° E., N. 30° E.		
Three-quarters ville				
Total number of joints with strike N. 10°-80° E.				41
" " " N. 10°-70° W.				31
" " " N.-S.				12
" " " E.-W.				9

TABLE SHOWING THE DISTRIBUTION AND STRIKE OF THE DIKES
OF BASIC ERUPTIVE ROCKS OF THE COASTAL PLAIN AND THE
NORTHEASTERN PIEDMONT BELT.

Locality.	County.	Strike of Dike.	Width of Dike in ft.
Western limits of Rockingham.....	Richmond.	N.-S.	100 +
Two and a half miles west of Rockingham.....	"	NW.-SE.	25 +
Three and a half miles west of Rockingham.....	"	N.-S.	150 +
Ten miles north of Wilson, granite quarry.....	Wilson.	NW.-SE.	20
West limits of Wadesboro.....	Anson.	NW.-SE.	...
One and a quarter miles west of Wadesboro.....	"	N.-S.	1 +
Two and a quarter miles west of Wadesboro; two parallel dikes	"	N.-S.	...
Two and three-quarter miles west of Wadesboro; two par- allel dikes	"	N. 35° W.	25 +
Three miles west of Wadesboro.....	"	N. 30°-35° W.	20
Three to three and three-quarter miles west of Wades- boro; eight or more parallel dikes.....	"	N. 20°-35° W.	4-50 +
One mile northwest of Wadesboro.....	"	N.-S.	1 +
One and a quarter miles northwest of Wadesboro; two parallel dikes	"	N. 30° W.	100 +
One-half mile east of Wadesboro.....	"	N. 10° W.	25 +
One and a half miles east of Wadesboro.....	"	N. 10° W.	25 +
Three miles east of Wadesboro; three parallel dikes.....	"	N. 20° W.	6 +
Three and a quarter miles east of Wadesboro; two paral- lel dikes	"	NW.-SE.	25 +
One mile east of Lilesville.....	"	N. 20° W.	25 +
One and a quarter miles east of Lilesville.....	"	N. 20° W.	140
Two miles northeast of Franklinton.....	Franklin.	NW.-SE.	...
Two and a half miles east of Franklinton.....	"	NW.-SE.	...
Three and a half miles east of Franklinton.....	"	NW.-SE.	300 +
Four miles west of Louisburg.....	"	NW.-SE.	20 +
One mile north of Rolesville.....	Wake.	N. 20° E.	...
Total number of dikes with strike N. 10°-45° + W.			17
" " " N. 20° E.			1
" " " N.-S.			5

TABLE SHOWING THE STRIKE OF THE JOINTS PENETRATING
THE GRANITES OF THE COASTAL PLAIN AND THE NORTH-
EASTERN PIEDMONT BELT.

Locality.	County.	Strike of Joints.		
miles north of Raleigh.....	Wake.	N. 20° E., N. 80° E.		E.-W.
east of Wyatt station.....	"	N. 20° E.		E.-W.
quarters of a mile northwest of Roles-	"	N. 20° E.	N. 80° W.	E.-W.
es northwest of Raleigh.....	"		N. 80° W.	N.-S.
sits of Raleigh.....	"			E.-W.
sits of Raleigh.....	"			
er at Louisburg.....	Franklin.	N. 80° E.	N. 80° W., N. 20° W.	N.-S.
ter of a mile north of Lilesville.....	Anson.	N. 70° E.	N. 20° W.	N.-S.
l a half miles south of Wadesboro....	"	N. 30° E.	N. 60° W.	
nits of Warrenton.....	Warren.	N. 30° E., N. 60° E.		
es north of Warren Plains.....	"	N. 45° E., N. 10° E.	N. 60° W.	
sea Crk., three miles south of Wilson.	Wilson.	N. 50° E.	N. 70° W.	N.-S.
dles north of Elm City (Toismot).....	"	N. 40° E.	N. 80° W.	
e north of Rocky Mount.....	Edgecombe.	N. 45° E.	N. 80° W., N. 80° W.	N.-S.
se quarries, Greystone station.....	Vance.	N. 60° E.		E.-W., N.-S.
les north of Greystone.....	"		N. 45° W.	E.-W., N.-S.
iles north of Greystone.....	"			E.-W.
st limits of Henderson.....	"	N. 25° E.	N. 70° W.	
Total number of joints with strike N. 10°-80° E.				16
" " " N. 20°-80° W.				13
" " " N.-W.				7
" " " N.-S.				7

CHAPTER IV.

THE CALCAREOUS ROCKS: LIMESTONES AND MARBLES.

VARIETIES.

Under this head are included a large and variable series of rocks composed essentially of carbonate of lime alone, or of carbonates of lime and magnesia, though frequently rendered quite impure through the presence of clayey matter, iron oxides, free silica or silicate minerals. They have originated through the induration and, in some cases, metamorphism of beds of calcareous mud, shell and coral remains formed on ancient sea-bottoms.

Many varietal names are given to these rocks, according as they vary in composition, color, structure or even uses to which they are put. The terms *argillaceous*, *siliceous* and *ferruginous*, are applied to such as carry an appreciable quantity of these substances, similarly as is the case with the sandstone. Hydraulic limestone is an impure siliceous and argillaceous variety used for making hydraulic lime. Often a part of the lime is replaced by magnesia giving rise to magnesian limestones, or if the magnesia occurs to the amount of 45.6% of the entire amount, the stone is called a *dolomite*. An oölitic limestone is one in which the individual particles are in the form of rounded, nearly spherical particles like the roe of a fish. The so-called Bedford (Indiana) stone is of this type, but such are not known to occur in North Carolina. A fossiliferous limestone is one carrying fossils; a coral, or shell limestone one containing coral or shell remains, etc. Many limestones or dolomites have undergone just the right amount of induration, or metamorphism, to impart to them such colors and textural qualities as make them desirable as marbles. In short, a marble, proper, is but a limestone or dolomite of such appearance as to make it suitable for decorative, or the finer grades of building work. Many marbles are so coarsely crystalline and of such color as to unfit them for decorative purposes, but are eminently suited for fine structural or monumental work.

The color of marbles and limestones in general is quite variable. A pure limestone or dolomite is white; gray or blue-gray and black colors are due to the presence of organic matter, i. e., carbon. The pink and

red or green colors are due as a rule to the presence of iron in some of its forms. In many marbles, and particularly the dolomitic varieties, the impurities have crystallized in the form of some variety of amphibole, pyroxene or mica, or as free quartz, magnetite, iron pyrites, graphite, etc.

Such minerals as a rule exert a detrimental effect, as noted in the chapters on weathering.

STRUCTURE.

In structure the stones classed under this head are quite variable. Those which have undergone little metamorphism are often so fine-grained as to seem quite amorphous and may carry numerous more or less conspicuous fossil remains. Metamorphism is invariably productive of crystallization, and all grades of texture, from that which is too fine to be visible to the unaided eye, to that in which the individual particles are an inch or more in length are common. Fig. A, Pl. XXVII, shows the structure of an ordinary marble, as seen under the microscope. The dolomitic varieties are more inclined to a granular structure than are the limestones.

Occasional calcareous rocks are met with in which the beds have been, by earth movements, shattered like so much glass and the fragments again recemented into a more or less solid mass, forming thus breccia marbles which are often of great beauty. Many of the so-called Numidian marbles are of this type. In other cases the original limestone beds have been broken into fragments and the individual particles tumbled about by wave action until more or less rounded like the pebbles on a modern beach, and the whole, in the form of a coarse and quite variable gravel, once more cemented by calcareous matter to form beds sufficiently firm for the production of marbles. The beds of calcareous Triassic conglomerate near Point of Rocks and elsewhere in Maryland are of this type.

WEATHERING QUALITIES.

Pure limestones suffer most severely on exposure through the solvent action of rainwater. Nevertheless, as the solvent action goes on very slowly, they weather away smoothly and evenly, and rarely become unsightly. With granular types, particularly dolomitic forms, or such as are mixtures of dolomite and calcite, a granulation results, the stone becoming rough and friable on the immediate surface and ultimately falling away to sand. Stones of uneven, laminated structure, naturally weather unevenly, some of the layers or laminæ giving way before others.

Included minerals like tremolite are inclined to weather out on the immediate surface, giving the stone a pitted appearance. Limestones, being sedimentary rocks, nearly always show bedding lines, although these may be quite inconspicuous in small specimens. Closely adjacent beds may vary greatly in color, texture, and quality. Often good sound beds are separated from one another by impure, shaley layers, or layers containing so large a percentage of impurities as to make them quite undesirable. The omnipresent pyrite is particularly common in limestones, and in the white varieties is harmful in producing a staining, rendered the more conspicuous from the whiteness of the stone.

METHODS OF WORKING AND QUARRYING.

Owing to their softness, the limestones and marbles may be cut and moulded into a variety of forms, either by hand or machine methods. They may be sawn into slabs by reciprocating saws fed by sand, turned on lathes, and the more compact varieties highly polished. In quarrying, machines are largely used, the blocks being first freed at the sides and ends by channelling, and then at the bottom by undercutting or gadding. Powder or explosives of any kind are never used in quarrying high-grade material, as the tenderness of the stone renders it liable to shattering, or, at least, to incipient fracture. These matters are sufficiently discussed elsewhere (see p. 244 and Pl. XXVI, B).

USES.

The highest grades of marbles are used only in interior decorative work and for statuary purposes. For the latter only the white, evenly saccharoidal varieties are suited. Such have not yet been found within the limits of North Carolina. For interior decoration, the colored varieties are most desirable, though the white is also used. In the form of balustrades, railings, wainscotings, mantels, and tilings their use is almost universal. The coarser varieties find a wide use for the higher grades of buildings, this being particularly true of the dolomitic varieties like those north of Baltimore in Maryland and in northern Georgia. In years past marble was the chief material used for monumental and tombstone work, though it is now being largely superseded by granite.

MARBLE.

GEOGRAPHICAL DISTRIBUTION.

Limestone, either in the form of marble or the common compact variety, is not an abundant rock in North Carolina. In the southeastern

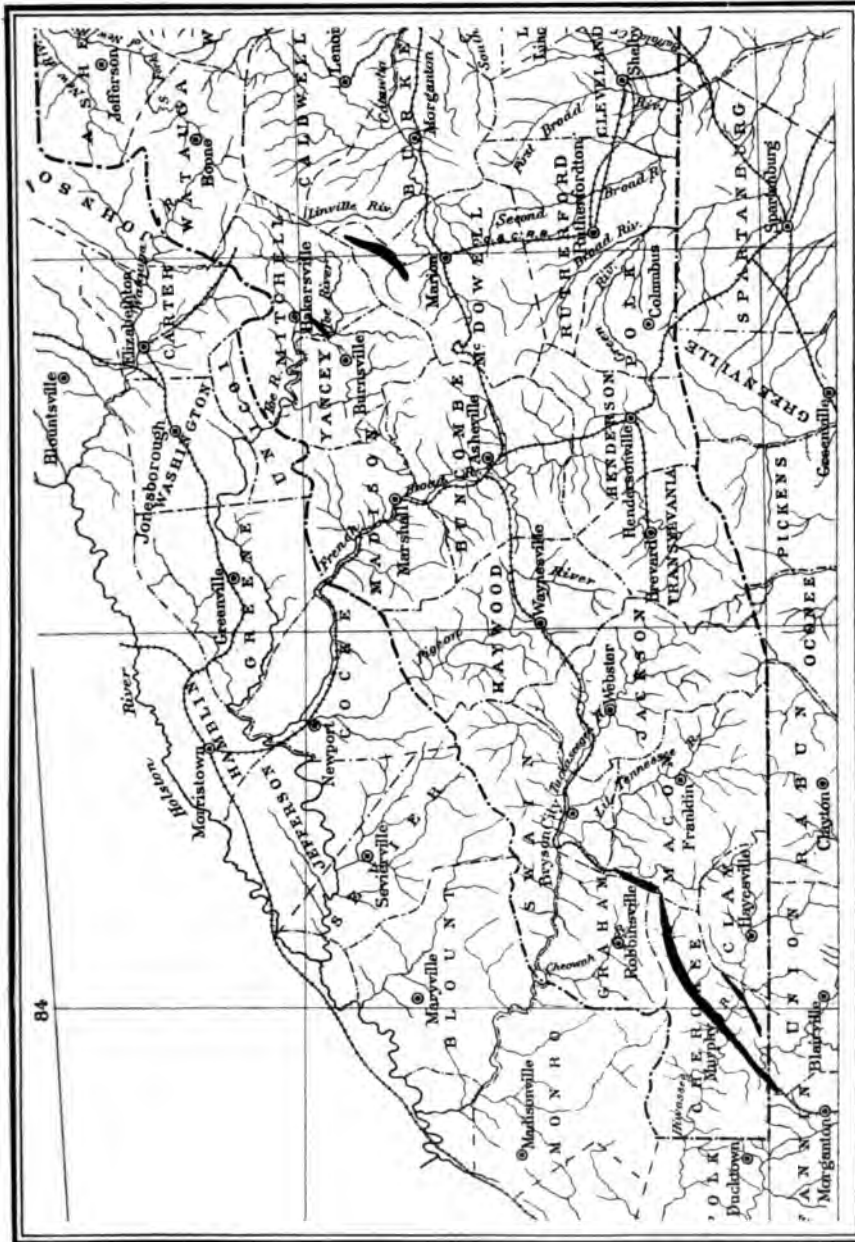


FIG. 3.—Map of western portion of North Carolina showing distribution of marble beds.

Only one block could be found that showed the original surface. This surface was simply a net-work of four distinct sets of joints from 1 to 10 inches apart.

The quarry was also very unfavorably located, being in a low-lying valley at the very edge of a small stream. The stripping was from 4 to 7 feet, and there was no way of draining the place except by pumping. It was, however, well located as regards facilities for shipping, being almost on the right-of-way of the A. K. & N. Ry.

In a cut on this same railroad, about $\frac{1}{2}$ mile southwest of Kinsey and perhaps $3\frac{1}{2}$ miles from the above described place, is an exposure of impure marble of fairly fine grain and of a dirty white color. The stone, in addition to the impurities, which consist of much tremolite, more or less altered to talc, quartz in both small veins and irregular patches, and pyrite, is cut by four distinct sets of joints. Two of these sets are quite prominent, having a trend of N. 40° E. and N. 50° W., and varying from a few inches to a very few feet apart. The other sets, while subordinate, are also very close.

The impurities are probably due to nearness of the outcrop to the contact with the quartzite, since another similar exposure about 150 yards nearer the station is nearly free from such minerals. Indeed, this second outcrop is of much better stone than the first, being a fine-grained white marble, fairly uniform in both color and texture. But, like the other, it is literally cut to pieces by joints.

THE KINSEY QUARRY.

This long since abandoned quarry is located at a small station of the same name. It now consists of a hole about 100 feet by 80 feet and about 50 feet deep, partly filled with water, and round which are piles of discarded marble and a quantity of more or less dilapidated quarry machinery.

The stone is rather coarsely crystalline and the majority of it is of a dark blue gray, more or less mottled and streaked with white, although much of it is a light gray color and a few blocks were noticed that showed a slight tinge of pink interbanded with the light gray.

The joints are so numerous and close (four sets, two prominent and two subordinate, and varying from a few inches to 5 or 6 feet) that it was impossible to get enough solid stone to warrant operating the quarry.

The place for making the opening was ill-chosen, being so located that quite an area of land drains into it, and there was no way of getting rid of the water except pumping. The stripping also was heavy—from 8 to 12 feet.

These last features, while very detrimental to profitable quarrying, were not the cause of discontinuing the work. This was the closeness and prominence of the jointing.

No openings have been made in the beds between this place and the quarry of the National Marble Company at Regal, a flag station on the Southern Railway about $3\frac{1}{2}$ miles northeast of Murphy. Several natural outcrops may be seen between the two places, but these are generally small, sometimes only a few small boulders, and are of such a nature that they afford very little clue to the character of the underlying stone.

THE NATIONAL MARBLE COMPANY'S QUARRY.

The only marble quarry in operation in the State is located in the narrow valley of a small creek, a tributary of Valley River, about $3\frac{1}{2}$ miles northeast of Murphy. The beds of marble in which this quarry is being operated have a width of about 300 yards. The stone is of two colors—a dark bluish-gray, often streaked and mottled with white although in places apparently free from such mottling, and a more or less uniform white stone. The gray stone appears to lie between beds of the white. The beds have a strike of about N. 45° E. and dip about 50° S. 45° E.

The country-rock on the south is a calcareous quartz schist, which is literally filled with hexagonal crystals of biotite, and which grades gradually into a very hard and compact sandstone—almost a quartzite. The biotite gradually decreases in quantity as distance from the contact increases and is entirely absent from the quartzite. The rock lying next to the marble on the north is a typical mica-schist. The contact is very sharp, but the schist nearest the marble is more or less calcareous. Immediately at this, as well as at the south contact, there is more or less tremolite, often in large masses, which, in many instances, is to a greater or less degree altered to talc.

The marble, as well as the country rock, gives evidence of the intense dynamic forces to which rocks of the region have been subjected. This is shown not only by the jointing, which is very prominent and close, and by the secondary minerals developed at and near the contacts, but even by the very texture of the marble. The interlocking grains of calcite or dolomite, of which the stone is composed, are invariably more or less elongated and always have their longer diameters roughly parallel. This tendency toward schistosity, if it may be so called, seems to be also parallel with the bedding planes of the rock. This texture, while not very prominent in this particular quarry, is, in some instances, so pronounced that the marble is distinctly platy or schistose and consequently worthless as a

building stone. This shearing is much less prominent in the blue-gray than in the white, which is finer-grained and apparently a more delicate rock than the dark-colored stone. This is true, not only of the stone of this particular exposure, but also of all the light-colored stone of the whole marble deposit.

There are three distinct sets of joints in the stone of this opening, two of which, trending N. 40° W. and N. 20° E. respectively, are quite prominent. The third set is subordinate but is of sufficient importance to cause considerable waste in quarrying. The joints of the two prominent sets are from a few inches to a few feet apart, usually 2 to 6 feet.

The texture of the stone seems to be quite uniform for each color, the gray being always of a medium grain and the white always fine. The gray marble is said to be used wholly for monuments, headstones, etc. The best grade of the mottled marble could probably be used for interior decoration, but as a rule, the color is too sombre and monotonous for such uses. As a general building stone, this gray marble, if placed upon the market, would meet with considerable favor. It is very firm and compact and contains no injurious impurities.

The present operations were begun in May, 1902, and have at date of writing hardly gotten beyond the exploratory stage (see A and B, Pl. XXVI). The superficial beds were found to be considerably injured by erosion channels, which in some instances, were of large size, and in one or two cases to extend to depths of from 12 to 18 feet. However, the last "floor" which was taken up contained only one small opening of this character, and it is probable that no more of them will be encountered. Certainly none will be found below the drainage level. Since the opening is in a low, narrow valley, there is no way of draining except by pumping, nor is there any convenient way of disposing of the waste material. What little marketable stone has as yet been taken out is said to have found a ready market for monumental purposes. The stone is shipped in the rough to the marble works of Capt. T. M. Brady at Canton, Ga., and there sawed, dressed, and placed on the market.

The machinery installed consists of one fifteen-ton hoisting engine, four Sullivan channelling machines, three Ingersoll gadders, one derrick, and one quarry bar.

Following the marble beds to the northeastward from this place, there are found here and there, principally in the stream beds that cross the belt, several small outcrops, but of such a nature as to give almost no idea of the general character of the stone, except to show that it is still of the two prevailing colors before mentioned. In a few places, as on the J. T.



A. VIEW OF MARBLE QUARRY OF THE NATIONAL MARBLE COMPANY AT REGAL, CHEROKEE COUNTY.



B. QUARRY OF NATIONAL MARBLE COMPANY, REGAL, N. C., SHOWING CHANNELLERS AT WORK.

Hays' property near Tomotla, more or less prospecting has been done at different times. In no instance was this prospecting carried any further than borings with core drills, and, as far as could be ascertained, nothing was found that differed essentially from the stone at Regal, which has just been described.

During the summer of 1903 Mr. C. W. Meador, of Corinth, Miss., did some exploratory work in the marble beds near Marble Station, about 7 miles northeast of Regal. Several test holes, located so as to ascertain the character of as much stone as possible, were put down. These showed the two colors met with elsewhere, arranged in the same order, blue-gray, more or less streaked and mottled, stone alternating with light-colored beds.

The texture and color of the marble, so far as could be determined from the work done, is so nearly like that now being quarried at Regal, that a detailed description is unnecessary.

So far as shown by the records obtained, it appears that the marble beds at this place are not quite so thickly jointed as at the localities to the southwest. The thickness of the marble beds is much greater here than at any other point between this and the State line, the belt being more than one-half a mile wide, while the average width heretofore has not been more than 300 yards. The dip here is practically the same as at the other places, about 40° S. 45° E. The stripping is from 8 to 16 feet, and consists of soil, clay, and stream wash—boulders and gravel. Since the marble occurs in the lowest ground of the region, it is evident that there will be more or less trouble from water and also that there will be some inconvenience in disposing of waste material.

The marble beds attain their greatest width, about three-fourths of a mile east of the place just mentioned, and retain it with more or less variation to perhaps $1\frac{1}{2}$ miles east of Andrews, a distance of about 8 miles. It is within this area that the most promising marble of the whole belt is found. The stone throughout the entire area is buried to a depth of from 5 to 20 feet, and there are few outcrops, though occasionally, as near Andrews, there are some fair-sized exposures. The largest and most favorable of these occurs in the Valley River bank in the eastern limits of the town.

The marble here is from medium to coarse grain—considerably coarser than that at Marble, Regal, and other places before mentioned. The color varies from light to dark bluish-gray. Sometimes the two colors are quite uniform, and again both are prettily mottled and streaked with either lighter or darker bands. Upon close inspection many small particles or specks are seen to be distributed irregularly through the mass of the

coarser portions of the stone. Under the microscope these are found to be irregularly-shaped pieces of some carbonaceous material, probably graphitic in character. These specks are most abundant at and near the peripheries of the various interlocking crystals that make up the stone, though to a less extent in their interior. To this cause may be ascribed the color of the blue-gray stone. A thin section of this stone, when examined under the microscope is seen to be made up of numerous medium-sized, irregular, clear, calcite granules, which are filled with very small particles exactly like the larger ones in the coarser stone, though in this case the distribution is much more even. The particles, though more numerous at the boundaries of the crystals, are also very abundant in their interior.

This rock also shows the effects of shearing, the various component crystals being slightly elongated and arranged with their longer axes roughly parallel. However, this tendency toward schistosity is much less prominent here than at the other places before described. This stone, when compared with that of the other localities, is seen to be remarkably free from joints.

This exposure at Andrews has an area of about 20 by 30 feet, and from this two sound blocks each 8 by 10 feet could be obtained. There seem to be only two sets of joints. These trend N. 20° or 30° E., and N. 70° W., respectively. There is a vertical exposure of about 5 feet and throughout this there is little or no variation of texture. The color consists of alternating bands and streaks of light and dark.

Although the beds here have not been exploited, the indications are more favorable for sound stone, free from joints than at any point thus far examined in the entire belt. The material is perhaps too coarsely crystalline to find a wide demand for decorative work, but is apparently well adapted for general building and monumental purposes. It is also favorably located for quarrying. Stripping would vary from 6 to 15 feet, and would consist entirely of soil and stream boulders and gravel. Shipping facilities are good, the outcrop being only a very short distance from the Southern Railway. It is quite probable also that with some expense the Valley River could be made to furnish power for sawing and dressing the stone, and probably, for operating the entire plant.

Dark bluish-gray marble, similar in every respect to the above described stone, occurs on Col. Chas. N. Hickerson's plantation, 1½ miles west of Andrews. More or less prospecting was done here several years ago. This work, it is said, showed that the gray marble, while cut by many joints, is probably massive enough for profitable quarrying. The

exploratory work was done with a one-inch diamond drill. It is said that cores from 5 to 7 feet long, entirely free from joints, were frequently taken out.

There are also many small exposures of white marble along the Valley River on this farm. The stone is apparently exactly like the white marble at Regal, both in color, texture, and also like that stone in the number and closeness of the joints. Stripping and facilities for shipping are the same as at Andrews.

Two miles east of Andrews, on a farm belonging to Mr. J. McWhitaker, are several exposures of marble which, with one exception, do not differ essentially in color and texture from the other outcrops in the vicinity of Andrews. The beds are much narrower and the forces of deformation seem to have been more intense here than elsewhere, the stone being literally cut to pieces by four distinct sets of very prominent and close joints, varying from a few inches to 2 to 3 feet apart.

The exposure referred to above as an exception occurs about one-half mile farther east than those just mentioned. The marble here is of medium grain and bluish-gray in color. It is peculiar in that there are two sets of lines, light and dark, alternating with each other, very close together, which intersect in such a manner as to give an indistinct checked appearance.

The beds of this stone, while more or less broken, are apparently in much better condition than those a short distance farther down the stream, and it is possible that exploration would expose stone that could be quarried.

The outcrop occurs at a spring near a house occupied by a Mr. William Young, but is not very favorably located, being nearly a mile from the railroad, and in a swampy ground where there is certain to be more or less trouble from water. Stripping would also be heavy, and there is no convenient dumping ground for waste stone.

The marble beds, after the flexure or curve just east of Andrews, assume their usual northeast trend, and with a slight intermission near Rhodo, a flag station on the Southern Railway, are continuous to a place one-half mile west of Tipton (Red Marble Gap), where they terminate—pinched out as it were. Throughout this distance outcrops may be seen here and there, none of which appear at all promising. The stone, while sometimes of favorable color and texture, is invariably either broken by joints into small rhomboidal blocks, or has been so badly sheared that it is more or less schistose or platy—in some instances decidedly so.

It will be noted that a narrow belt of marble is indicated on the map

(p. 191) as lying about 7 miles southeast of the main belt, just described, and extending with one or two slight interruptions from Martins Creek 3 miles northwest of Ballew P. O. to Peachtree Creek, crossing the Hiwassee River at Brasstown. The stone occurring here has much the same color as that in the main belt, but the beds are so badly jointed and contain so many impurities that it is doubtful if they can be made to yield anything of value.

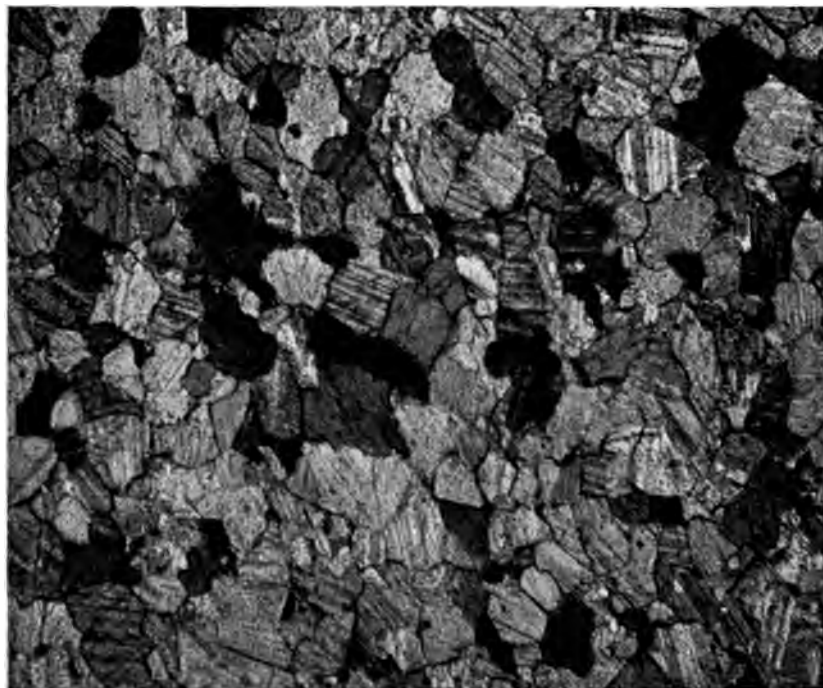
SWAIN COUNTY.

Passing over the mountain at Red Marble Gap, the marble beds are next found about one-half mile northeast of Topton. They extend as elongated lens-shaped masses, with one or two short intermissions, to about one mile northeast of Hewitts, where they are crossed by the Nantahala River, beyond which they pinch out.

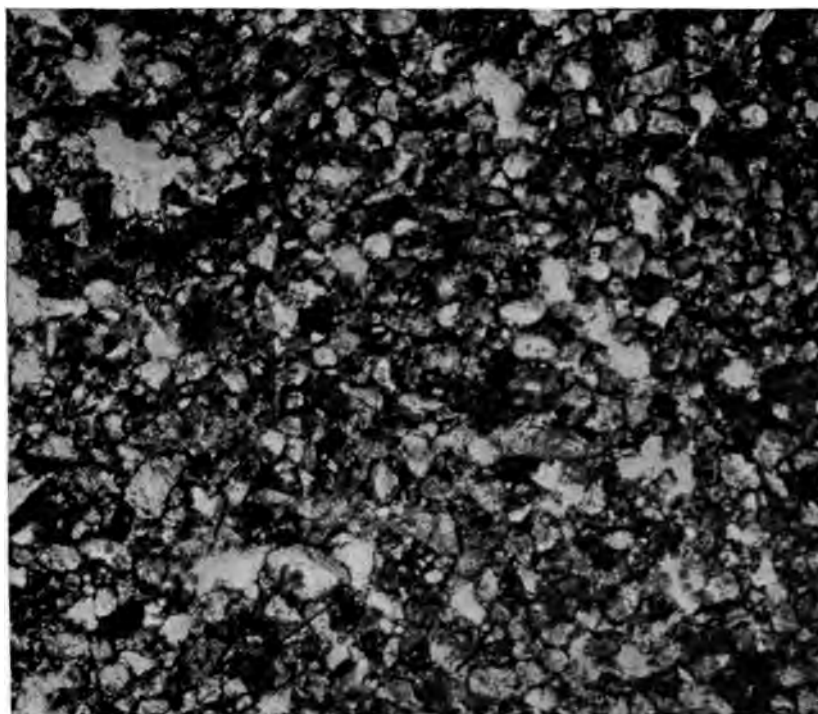
The stone in these beds is quite different in color and texture from that on the west side of Red Marble Gap. It varies from a light-gray to almost a black, and from a cream-white to a delicate flesh color or pink. Sometimes both colors are solid; sometimes irregular, alternating bands or patches of each occur. In many instances there is a decided tinge of green in the rock. This last is due to the development of a secondary green mineral, probably serpentine, which varies greatly in the amount present, and seems to extend through the rock parallel with the schistosity. This combination of various shades of cream and pink, each more or less interbanded with green, is very pretty. However, it seems that this stone will, as a rule, not acquire as smooth a surface or take as high a polish as might be desired.

This stone is generally decidedly schistose, the platy or schistose structure being so prominent in some instances that the stone in weathering breaks up into either thin flat plates or into long, narrow blocks resembling sticks of cord wood.

When a thin section of this stone is put under the microscope, the individual crystals of the rock are seen to be very much elongated in one direction, and to have their longest diameters arranged parallel with each other (see A, of Plate XXVII). It is this feature which causes the apparent schistosity. Though all the stone of these beds shows this schistosity in greater or less degree, the conditions in one or two places seem to be such that it might be possible to obtain marketable stone. One of these places is on the property of the North Carolina Talc and Mining Company at Hewitts Station. The outcrop, at which some exploratory work has been done, occurs on the mountain



A. MICRO-STRUCTURE OF MARBLE FROM HEWITTS, SWAIN COUNTY.



B. MICRO-STRUCTURE OF SANDSTONE FROM WADESBORO, ANSON COUNTY.

side about one-half mile southwest of the station and 300 or 400 feet above the railroad. The stone is all fine-grained and in color does not differ essentially from that above-mentioned, i. e. a cream white to delicate pink streaked and mottled with green, a medium to light steel-gray or blue-gray, and a very dark-gray, almost black. It also shows a distinct tendency toward the above-mentioned schistosity or "platiness," but not to such an extent as to prevent the obtaining of marketable slabs, provided the stone be sawed parallel with the schistosity, which, indeed, is the proper way to cut it in order to get the best results as regards color.

This marble contains more or less impurities such as tremolite, pyrite, and some quartz. The tremolite is found most abundantly near the contacts with the country rock, and very sparingly, if at all, in other portions of the stone. The amount of pyrite apparently varies with the color of the stone—the darker the color, the more pyrite. The quartz occurs as irregular elongated patches, as small veins that generally run parallel with the schistosity of the rock, and as elongated grains varying greatly in size, though usually very small. These impurities are by no means regularly distributed through the rock. They are all, except the pyrite, most numerous at and near the contacts and diminish in quantity as distance from contacts increases, so that much of the stone is apparently free from them. The pyrite is so abundant in the very dark stone that it is of very doubtful value.

It appears that there are at least two parallel-lying beds of this stone, from one of which comes the various shades of gray, and from the other the light-colored rock. The thickness of these beds could not be determined. However, the following drill records furnished by Mr. F. R. Hewitt, manager of the company that owns the marble, will give some idea of the relation of the different colors. Both holes were bored as nearly as possible at right angles to the schistosity, which is apparently parallel with the dip of the beds.

Hole No. 1.

- | | |
|--|--------|
| 1. Bluish gray, mottled and banded with white..... | 20 ft. |
| 2. Purplish pink, color not uniform, more or less green
interbanded | 12 " |
| 3. Pink with more or less green, green increasing with depth. | 30 " |

Hole No. 2.

- | | |
|---|--------------|
| 1. Bluish gray | 20 or 30 ft. |
| 2. Pink with some green streaks..... | 8 or 10 " |
| 3. Purplish pink, mottled with green..... | 20 " |
| 4. Cream white | 7 or 10 " |

This stone is very favorably located for quarrying. A face of about one-fourth mile by 100 feet could be exposed with very little stripping. This face would be parallel with the railroad and about 200 feet above it. Thus the stone could be easily put upon the cars. Also the Nantahala River runs at the edge of the marble beds and parallel with them and could be made to furnish ample power for operating a quarry.

MCDOWELL COUNTY.

A great body of limestone, portions of which may be termed marble, occurs along and near the North Fork of the Catawba River in the northern part of the County. The stone extends as a series of usually large, disconnected outcrops, from Woodlawn P. O., 10 miles north of Marion, to the "head" of North Cove, 15 miles northeast of Woodlawn.

By far the greater portion of the stone is only a dolomitic limestone of varying purity, generally containing such impurities as quartz, tremolite, and talcose minerals in small quantity, and sometimes much pyrite, especially in the darker portions of the stone. However, often there appears to be no other impurity than a small amount of quartz, which occurs in irregular grains and as thin veins which represent former joints and fractures in the rock; and sometimes even this appears to be lacking or present in only very small amount.

Much of this stone, while probably not suitable for high grade work, could be used to good advantage as a general building stone, the color and texture of the rock, as a rule, being favorable for such uses. However, there is one feature of this stone which seriously injures all, and renders the greater part of it, absolutely worthless even as a building stone. This is the number of, and the closeness of the joints, there being always two, generally three, and often four distinct sets of close cutting joints. While it is true that this feature renders practically all the exposed stone worthless, it is possible that exploration will show beds free enough from joints to warrant quarrying, since much of the stone, in the most favorable places, is unexposed. (It must be borne in mind that all the stone thus rendered useless for building purposes is of value as road material.) Results of tests of this rock for road material are given on p. 266.

The statements above made apply to probably all portions of rock. The portion of the stone that has been termed marble is usually very fine-grained. The color is white with a tendency toward a blue tinge—somewhat like the color of a white cloth that has been "blued" too much in washing, and is quite uniform. The stone is hard and compact and breaks to a sharp edge. It contains varying quantities of quartz, which

occurs as small grains scattered irregularly throughout the stone—apparently sand grains that were deposited when the limestone beds were themselves deposited—as small masses of various shapes and as thin seams or veins that mark former joints and fractures. Sometimes there is only a very small amount of this quartz present, while again the rock may be so siliceous that it may be called a calcareous sandstone. This last condition is seen only very close to the southeast contact with the country-rock, which, on this side of the marble, is sandstone or quartz schist. As a rule, the best beds contain only a very small amount of impurity of any kind.

The marble, while it is seriously injured by joints, is in much better condition in this respect than that portion of the stone which has been called limestone. As a rule, there are only two sets of joints varying from less than a foot to perhaps 8 feet apart. Thus, in some places, blocks of stone of good size may be obtained. The joints trend N. 20°-30° E. and N. 50°-60° W. and the beds of stone dip 45°-50° S. 45° ± E.

Some years ago, the State Geological Survey did considerable exploratory work in the marble beds on Col. J. G. Yancey's plantation at Woodlawn with a core drill. Several holes were put down in such a manner as to include a thickness of nearly a thousand feet of the stone. Records made at the time this work was done say that while much of the stone is rendered worthless by the jointing, some portions of it are fairly free from joints and will thus furnish valuable stone.¹ The cores from this drilling are now in the State Museum at Raleigh and were examined during the preparation of this report, but they are badly broken and furnish little satisfactory information as to the condition of the beds from which they were taken.

This stone is at present practically inaccessible, being 10 miles from a railroad, in a mountainous country where the country roads are in very poor condition. However, the South and Western Railway has a survey of a proposed extension running within a mile of the most favorable outcrops of the marble, and it seems probable that the road will be built in the very near future. In fact the road is now built and trains are running within 12 miles of the outcrops.

MITCHELL COUNTY.

One of the most favorable marbles in the State has recently been exposed in a cut on the South and Western Railway, on the north bank of North Toe River near the mouth of Sinkhole Creek, about 3½ miles above

¹ J. V. Lewis, First Biennial Report of the State Geologist, 1891-1892, p. 97.

Toe Cane station. The exposure consists of a bed of very pretty coarsely crystalline white marble, quite similar in color and texture to the white marble at Tate, Ga., about 60 feet thick, interbedded with typical mica schist. The rock is exceptionally pure and the texture is very uniform—in fact, the stone seems to be homogeneous throughout. Also judging from the exposed stone and the blocks which were blasted out while making the cut, it is remarkably free from joints. Many large blocks were noticed in the embankment and very few of them showed any traces of joints. From one piece a block of stone, perhaps 5x8x12 feet, entirely free from flaws, and uniform in color and texture, could be obtained.

The marble bed, while it may vary somewhat, has an average thickness of about 60 feet. It trends N. 20° or 30° E. and dips about 50° S. 45° E. It can be traced northeastward for about a mile from the outcrop at the railroad, the texture, purity, and color being remarkably uniform.

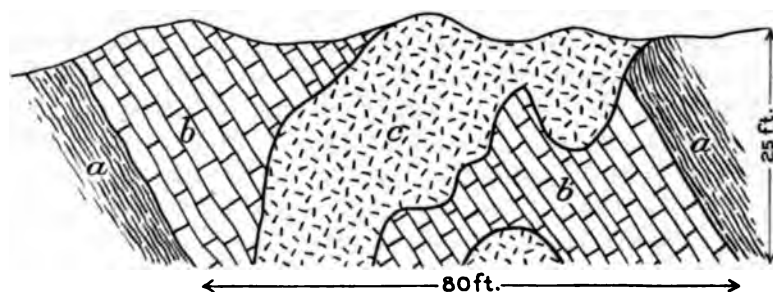


FIG. 4.—Pegmatitic dike (c) cutting the Mitchell County marble (b). The country rock is a contorted typical mica schist (a), which at the contact with the marble is quite calcareous.

The exposure is by no means continuous, but boulders may be seen sticking out of the ground here and there. The outcrop farthest distant from the railroad consists of only a few fair sized boulders on the mountain side near a house occupied by Mr. Howell. Another occurs on the north side of Sinkhole Creek on land belonging to Mr. W. F. Johnson. No outcrops could be found on the south side of the river.

A peculiar feature of this marble deposit, and one which detracts more or less from its value, is the occurrence of a large pegmatite vein in the midst of the marble (see Fig. 4). This vein consists of quartz and feldspar, with more or less mica in places. This pegmatite apparently extends the whole length of the marble bed and even farther, for it was traced over a mile beyond the last outcrop of marble. However, no indications of it were seen at the outcrop on Mr. Johnson's land.

The country rock is a much contorted typical mica-schist which at the contacts with the marble is quite calcareous.

This stone is favorably located for quarrying, being on a mountain side about 100 feet above the valley, thus affording natural drainage and space for disposal of waste material. The North Toe River, which runs within a few yards of the exposure, can at very little expense be made to furnish ample power for operating a quarry. Also the belt is crossed by the South and Western Railway, which makes connections with the Southern Railway at Johnson City, Tenn., 50 miles distant, thus affording easy outlet for any stone that might be ready for market.

LIMESTONE.

SOUTHEASTERN AREA.

In many counties of the southeastern portion of the State, especially Craven, Beaufort, Onslow, Duplin, Pender, New Hanover, and Brunswick, there occur deposits of more or less consolidated marls and limestone of Eocene age.* These are made up for the most part of calcareous shells and fragments of shells cemented with carbonate of lime. This stone is locally known as "shell rock" and in texture is very coarse, there being much space between the individual shells and fragments. Between this condition and a fairly fine-grained rock, which very closely resembles the coquina stone of Florida, every gradation is found. This material is not continuously consolidated over any large extent of territory, but is found in the condition of limestone only in local areas of varying size, sometimes only a few square yards in extent, and again the solid beds may be continuous for several hundred yards. The rock is usually covered with from a few to many feet of soil and is seen outcropping only in a few places along the streams. It is always soft and easily worked when first taken out of the ground but hardens very materially as it remains exposed to the sunlight and air. Indeed, it is so soft when first taken out of the ground that it may be hewn and fashioned into blocks with very crude tools. Some areas of it have furnished stone for local use in stone walls, foundations, piers and jetties, but by far the vast majority of it is suitable only for burning into lime or as road metal. Another use to which this marl and limestone may possibly be put is the manufacture of cement. For this purpose it would have to be used in connection with clay of the requisite composition, and indeed it appears

* For a full discussion of the marls and shell limestones of Eastern North Carolina, see report of the N. C. Geol. Survey, 1852, pp. 2-112, E. Emmons, State Geologist.

from the small amount of investigation done upon the subject that in many localities clay suitable for such use may be found in close proximity to the limestone. For value as road metal, see p. 266.

Some of the promising localities of this shell rock and marl are along both the Neuse and Trent rivers in the vicinity of Newbern. It is exposed in the banks of these streams in many places within distances of from one to 20 miles from Newbern. In some exposures near the city the stone has been quarried for local use in foundations, on the roads as macadam, etc. A rather pretty coarse shell rock was quarried on the Trent River a short distance from Newbern some years ago and used in the walls and archways enclosing the city cemetery. The open texture of the rock gives this work a rustic appearance that is very attractive.

At many places in the counties above named, shell rock very similar to that in Craven County has been located and in a few places, as the city quarry and other localities in the vicinity of Wilmington, the stone has been opened for local use; also it was worked at Castle Hayne a few years ago as a phosphate rock. A rather promising exposure of a compact, stratified phase of this limestone is known to occur in the vicinity of Southport, in Brunswick County. At this point a bluff of the limestone, probably 15 feet high, is showing in the bank of a large creek, and from all appearances, this is probably the largest and best body of this rock in the State. It has not been opened, but sufficient exploratory work has been done to show that the deposit is of considerable value. The stream upon which it is located is large enough to allow the passage of boats of 15 tons burden, thus affording water transportation for this stone in case it should be quarried. The following is a chemical analysis of the rock, furnished by Mr. E. A. Parmelee, of Wilmington, N. C., the owner of the property:*

Analysis of Limestone from Southport, N. C.

SiO ₂	12.04
Fe ₂ O ₃	2.02
Al ₂ O ₃	1.44
CaO	33.56
MgO	8.79
Loss on Ignition (includes CO ₂)	37.96
Undetermined	4.19
<hr/>	
Total	100%

* Analysis by C. N. Forrest, Long Island City, New York.

PIEDMONT AND MOUNTAIN AREAS.

In a few of the Piedmont and mountain counties of the State occasional areas of limestone occur. These are usually small beds of limestone intercalated in the schists and gneisses. In extent they are for the most part narrow lenses varying from a few to 200 or 300 feet in width and from a few hundred yards to several miles in length. So far as known, none of this limestone is of such quality as to be used for building purposes except to supply purely local demands. But a great deal of the stone will burn to a good grade of lime, and for this purpose it is of considerable economic importance. Much of this rock, possessing as it does, a high cementing value and a fair resistance to wear, makes an excellent road metal.

There are a number of localities in these areas where the stone apparently occurs in sufficient quantity to be of economic value as a source of lime. In Buncombe County, about 2 miles north of Fletcher, Henderson County, a station on the Southern Railway, a limestone quarry has recently been opened by the Blue Ridge Lime Company.⁴ It is on the same limestone strata as the old Lance lime quarry, but 600 to 700 feet distant from this on what is known as the Westfeldt property. The Company have erected two kilns which have a capacity of 700 bushels per day (A, Plate XXVIII). The quarry and kilns are connected by a tramway with the railroad at Fletcher. The limestone is of a peculiarly fine-grained structure with a very smooth touch. Analyses of this stone by Mr. D. K. Pope of the United States Assay Office at Charlotte gave the following results:

Analyses of Limestone from Fletcher, N. C.

	I.	II.
	<i>Per Cent.</i>	<i>Per Cent.</i>
Silica	1.40	1.70
Alumina and ferric oxide .....	.58	.58
Lime	53.32	53.38
Magnesia	1.62	1.32
Carbonic acid	43.66	43.39
Total.....	100.58	100.37

There are little or no impurities in the limestone, and the calcium carbonate constitutes 95.32 per cent of the rock. A test was made also by Mr. Pope of this limestone by burning Sample I at a strong red heat for two hours, at the end of which time 95.74 per cent of the theoretical

⁴J. H. Pratt, N. C. Geolog. Survey, Economic Paper, No. 9, p. 76, 1906.

amount of lime was obtained. The stone burned easily and made a pure white lime. In Sample II, which was heated for two hours at a strong red heat, there was 90.3 per cent of the stone converted into lime, which was also a very white lime and gave no difficulty in burning. Another hour's heating would have converted practically all of the rock into lime.

In B of Plate XXVIII is shown a chimney that was built in the year 1846 by Mr. N. J. Lance from mortar made from air slacked lime obtained by burning limestone from the Lance quarry. The chimney stands as solid and erect to-day as when first built and the mortar is in almost perfect condition.

In Henderson County quite a large body of limestone occurs 7 to 10 miles west of Hendersonville, the county-seat, in the vicinity of Boilston. The limestone outcrops at intervals from about 3 to 5 miles northeast of Boilston to some distance above Brevard, the county-seat of Transylvania County. It is capped in many places by a schistose rock and is dipping approximately 40° S. E. On the land of Mr. J. F. Woodfin, about $\frac{3}{4}$ of a mile a little east of south of the Boilston gold mine, limestone has been worked for a little over 200 feet along the strike. The limestone apparently contains very little grit and is of a bluish tinge known locally as "blue limestone." Considerable of this limestone has been burned to lime, some of which has been used for fertilizing purposes. On the W. B. Allison farm, three-eighths of a mile due west of the Woodfin quarry the limestone is whiter in color and is known locally as "white limestone" to distinguish it from the "blue limestone" of the Woodfin quarry. A similar quarry has been opened on Bryson Ezell's farm 3 miles northeast of Allison's. Considerable of the lime burned from this limestone has been used for building purposes.

In Transylvania County kilns for burning limestone have been erected by W. O. and Joseph Miller, George Young, and Joshua Owen near Brevard. Most of the lime burned at these kilns has been used for fertilizing purposes. An outcrop of a limestone, which is more or less siliceous, forms a ridge known as Limestone Ridge on Bear Wallow Creek about $\frac{1}{2}$ of a mile above its junction with Toxaway River. The limestone outcrops prominently in the stream and on both sides in ridges that rise about 150 feet above the creek. Although this limestone is somewhat siliceous, it has for a number of years been quarried and burned, the lime being used for both building and fertilizing purposes.

In Macon County, near the headwaters of Ellijay Creek, near Cullohee Gap, limestone has been burned to lime for building and fertilizing purposes on the property of John Bryson. About one-half mile west of the



A. LIME KILNS OF THE BLUE RIDGE LIME COMPANY AT THE LANCE QUARRY, 2 MILES NORTH OF FLETCHER, N. C.



B. CHIMNEY BUILT IN 1846 WITH MORTAR MADE FROM LIME OBTAINED FROM THE LIMESTONE OF THE LANCE QUARRY.

10

11

Gap is the Haskett lime quarry that was worked quite extensively some years ago.

In Gaston County the most promising deposits are in the vicinity of Bessemer City and Kings Mountain. The stone at this point is said to make a first-class lime and considerable has been burned and used locally for building purposes. A similar limestone is found in a number of places in Lincoln and Catawba counties.

At Hot Springs, in Madison County, is one of the largest and best known limestone deposits in Western North Carolina. The rock occurs in inexhaustible quantities and may be seen forming a high bluff on the French Broad River about one mile below Hot Springs. The rock is too badly shattered and is not of proper quality for use as a building stone, but it has been used to some extent for burning into lime and is said to be well adapted for this purpose and to produce a good quality of lime. It also possesses a reasonably high cementing value and a fair resistance to wear, and consequently is well suited for use as road metal. For results of tests of this stone for road building purposes see page 266. In other places in this County small deposits of limestone occur as narrow lenses in the schists and gneisses. One of the largest of these is found on Little Laurel Creek just south of Allen Stand. The stone at this point is apparently a fairly pure limestone and will undoubtedly burn to an excellent quality of lime.

On the north fork of the Catawba River, in McDowell County, about 10 miles north of Marion, limestone occurs in large quantities and may be traced by means of disconnected outcrops from the plantation of Colonel J. G. Yancey (Woodlawn) to the head of North Cove, a distance of perhaps 15 miles. In some places, especially near Woodlawn, the stone is a fair grade of marble and offers considerable promise as a building stone (see page 202). For the most part, however, it is simply a badly shattered limestone or dolomite and can be used only as road metal or in the manufacture of lime. For results of tests of this stone for road building purposes see page 266.

Near Germantown in Stokes County a bed of limestone 40 to 50 feet thick occurs. This deposit was known and worked to supply stone for local use and for burning into lime prior to the Civil War. It was then known as "Bolejack quarry."⁵

⁵ Report on the Soils and Agriculture of the Lower Counties, and the Coal Fields of Rockingham, Stokes, Chatham, and Moore Counties, Report North Carolina Geological Survey, 1852, page 180, E. Emmons, State Geologist.

CHAPTER V.

THE SERPENTINES AND VERDANTIQUE MARBLES.

The rocks grouped under this head are invariably of secondary origin. They originate only through processes of chemical changes, or alteration, such as are all comprehended under the general name of *metasomatosi*s. The meaning of this word can be best explained as a process of indefinite substitution and replacement, that is to say, the original rock has been modified through the carrying away, by solution, of a portion of the original constituents and their replacement by others.

The serpentinous rocks of North Carolina have resulted mainly from the alteration of basic, igneous rocks of the nature of peridotites. These rocks are composed mainly of the silicate mineral olivine, with, it may be, enstatite, together with magnetite and chromic iron. Otherwise expressed, they are composed mainly of silica and magnesia with smaller amounts of alumina, iron and lime. The process of alteration has resulted, as a rule, in a loss of a portion of the original silica, a portion or all of the lime, where such existed, presumably part of the magnesia also, and an assumption of water, the processes being accompanied by an oxidation of the combined iron. In cases where the original rocks contained lime-bearing silicates, the lime set free has combined with carbonic acid to form carbonate of lime, or calcite, and been either carried away in solution, or re-crystallized as veins of spar. The iron oxides and sometimes carbonates of magnesia and iron also sometimes separate out in the same way, thus diversifying, and sometimes adding to the beauty of the stone.¹

The fact that the process of alteration, which gives rise to those serpentinous rocks is one of indefinite substitution and replacement, added to the differences in composition of the rocks from which such may have been derived, causes a considerable difference in composition among the various rocks to which the name serpentine is commonly applied. A pure serpentine consists of silica, magnesia and water in the following proportions:

¹ For full description of Peridotites and Serpentes see Vol. I, N. C. Geol. Survey, "Corundum and Peridotites of Western North Carolina," J. H. Pratt and J. V. Lewis.

Theoretical Composition of Serpentine.

	Per cent.
Silica, SiO_2	44.1
Magnesia, MgO	43.0
Water, H_2O	12.9
Total	100.0

As a matter of fact, however, nearly all serpentines are impure, showing a quite variable composition, the chief variations being in the percentage amounts of iron and alumina.

The normal color of the serpentines is some shade of green or yellow, though often diversified by red, brown, white or even black shades. The prevailing, though somewhat diversified greenish hues, are recognized in the name, which is derived from the Latin word *serpentinus* meaning serpent-like.

STRUCTURE.

In structure the serpentines are almost universally brecciated, though it may be so coarsely so that slabs and blocks of considerable size of uniformly even texture are obtainable. In cases where the original serpentinous fragments have been re-cemented by the deposition of the lime or magnesian carbonates along the line of fracture, a beautiful marble may result as is well exemplified in the celebrated Verde de Genova, and Verde de Prato marble of Italy. Ordinarily the serpentines are very compact and without evident crystalline structure, and have a somewhat greasy lustre and feel. The impure varieties are, however, often more or less porous.

WEATHERING QUALITIES.

Although composed of material so largely insoluble, the serpentines are not invariably of an enduring nature. This is due mainly to inequalities in texture and composition. The verdantique marbles, when exposed early, lose their polish and not infrequently open up along the numerous seams and joints by which even the best varieties are traversed, and become quite unsightly. Such should be used, therefore, only where protected from atmospheric action. The rough forms, used for general building are, as a rule, very durable, though even here inequalities in texture may bring about disastrous results. The stones are almost universally badly jointed, and if blocks of more than very moderate dimensions are used, defects are likely to develop on short exposure. Carefully selected, and used in rock faced or tool dressed work, the stone forms an admirable building material.

USES.

The uses to which the serpentines are put depend very largely on their colors and the possibility of obtaining blocks sufficiently sound to be sawed into slabs or turned into columns. The finer grades, often diversified by veins and dashes of white or gray, are used for interior decoration, under the name of verdantique marbles. Others, which will not yield slabs of such size as to make them desirable for this purpose are utilized in making small objects of ornamentation, such as bases for statues, vases, etc. The stone is sufficiently soft to be turned on a lathe, and hence, when the colors are good, is admirably adapted for such purposes. The great drawback to the use of the stone for wainscoting and like forms of decoration lies in its dark and cold color. In well lighted, sunny rooms, this objection is largely done away with and the effects produced through its use are often admirable. The rough, impure forms, such as will not polish, are used in many instances for general structural purposes. Many private and public buildings in the cities of Baltimore, Philadelphia, and Washington are constructed from such material brought mainly from Chester County, Pennsylvania, and adjacent portions of Maryland.

GEOGRAPHICAL DISTRIBUTION.

The distribution of the available serpentine in the State is limited largely to the counties of Buncombe, Caldwell, Madison, Watauga, Yancey, Wake, and Wilkes. It occurs in small quantities in nearly all the mountain counties,^{*} but as a rule the deposits are small and the color not suitable for ornamental purposes. In all of these localities the stone occurs in the form of dikes which are usually quite narrow, though they may extend for long distances. The material thus far found is almost invariably of a dull green to dark green color, though sometimes light yellowish green. It always contains an abundant sprinkling of dark granules and veinlets of chromic iron ore, which, however, so far as observed, do not injure the stone for purposes of general construction. No serpentine suitable for use as a high grade decorative stone has yet been found in quantity within the State limits.

BUNCOMBE COUNTY.

The serpentine dikes of this County are confined to the western portion of the County and are found as small, disconnected, lenticular outcrops extending irregularly from the vicinity of Canton northeastward to the

^{*} Corundum and Peridotites of Western North Carolina, J. H. Pratt and J. V. Lewis, Vol. I, N. C. Geol. Survey. See "Serpentine."

French Broad River near Alexander, and from thence northeastward to near Stockville. The outcrops are always small, seldom exceeding 30 feet in width and a few hundred yards in length. The color of the stone varies from a very dark green to a light yellowish—or grayish green, the dark green apparently being the prevailing color. All the outcrops are at present practically inaccessible, being in a mountainous region with few wagon roads, and from one to 10 or more miles from a railroad. A few of the most promising are located as follows:

On a farm belonging to Mr. W. L. Foster about $2\frac{1}{2}$ miles west from Olivette station on the Southern Railway, is probably the most favorable exposure of serpentine in the County. The dike, which has a width of from 16 to 20 feet, is exposed near the top of a small hill and in such a position that it could be opened with no very great expense. The stone varies in color from a dark green to a light yellowish green, the latter being, as far as could be determined, from the small exposure, the prevailing color. The stone near the surface is badly weathered and discolored, but a small amount of excavating, which was done some years ago, shows that at a depth of 10 or 15 feet it is hard and fresh.

Another exposure very much like the one just described occurs a short distance further southwest on land belonging to Mr. W. E. Pounder. The dike at this point is considerably wider than the outcrop on Mr. Foster's land, being about 40 feet. The color is not quite so desirable as the other stone, being for the most part of a light-gray or yellowish-green. It is also apparently very deeply weathered and thus not quite so favorable a stone.

One and a fourth miles above Alexander a 15 foot dike of dark green serpentine is exposed in a cut on the Southern Railway. The stone contains a considerable amount of chromic iron ore in the form of small veins and granules and is apparently so badly jointed that only small blocks could be obtained. Another outcrop of this same dike occurs about $1\frac{1}{4}$ miles northeast of this place. The exposure is best seen in the bed of Reems Creek about $\frac{3}{4}$ mile from its junction with the French Broad River. The stone at this place is of a beautiful dark green color—varying from a very dark green to a deep clear yellowish-green. It also appears to be more massive than the outcrops just described, and it is not impossible that some marketable serpentine may be obtained at this place.

Another exposure of similar stone occurs about one mile northwest of Weaverville,^a and extending in a series of disconnected outcrops the serpentine may be traced northeastward into Yancey County.

^a *Corundum and Peridotites of Western North Carolina*, J. H. Pratt and J. V. Lewis, Vol. I, N. C. Geol. Survey, pp. 105-106.

WILKES COUNTY.

One of the most favorable exposures of serpentine in the State occurs on Reddies River, about $11\frac{1}{2}$ miles northwest of North Wilkesboro. Messrs. Pratt and Lewis in their report on the Corundum and Peridotites of Western North Carolina make the following statements regarding the serpentine deposit:⁴

"The deposit (asbestos) near North Wilkesboro is within three-fourths of a mile of the railroad and occurs in a serpentine formation that is from 75 to about 200 feet in thickness and can be traced in a general N.W.-S.E. direction for nearly 600 yards. The deposit has been worked by means of an open cut 100 feet long, which was made on the land of Mr. J. B. Church. The cut varies in depth from 1 to 35 feet and near the surface the serpentine encountered was much decomposed and altered, but at lower depths a compact, dark green rock was found. This harder rock is similar to a bold outcrop of serpentine that occurs on a low hill about 300 yards a little east of south of this cut on land belonging to Mr. G. W. Hinshaw, of Winston, N. C. A similar outcrop of serpentine was observed on the summit of a hill 200 yards nearly north of the cut. In nearly all of this serpentine small seams of chrysotile asbestos were observed that varied in thickness from a quarter of an inch to nearly 2 inches, the thicker ones having been found in the bottom of the cut. These seams run at all angles through the rock and as the unaltered serpentine was encountered, the quality of the asbestos became better."

On another page⁵ in the same report this deposit is spoken of as follows:

"Another deposit (serpentine) that is worthy of investigation is the one in which asbestos occurs, near North Wilkesboro, Wilkes County. At the bottom of the cut made in prospecting for asbestos, the serpentine obtained was of good color (dark green), hard and compact and took a good polish. It is within three-fourths of a mile from the Southern Railway and water-power is available for sawing the stone."

MADISON COUNTY.

A series of small, disconnected, lenticular outcrops of serpentine extends across this County from near Boyd Gap northeastward to the Walnut Mountains. They cross the French Broad River near the mouth of Little Pine Creek about 2 miles west of Marshall. Near this point many small outcrops of serpentine, soapstone and dunite occur, but no work has been done at any of them, and since they are all in a mountainous

⁴Corundum and Peridotites of Western North Carolina, J. H. Pratt and J. V. Lewis, Vol. I, N. C. Geol. Survey, p. 394.

⁵Loc. cit., p. 399.

region, with very poor wagon roads and several miles from the railroad, they are at present wholly inaccessible.

Other deposits, often quite large and of dark-green to yellowish-green color, occur on Paint Fork of Ivy River in the northeastern portion of the County.* The color of the stone and the nature and size of a few of these outcrops, seem to indicate that exploratory work might show up serpentine suitable for building and decorative purposes. The outcrops are all far removed from the railroad and are at present inaccessible.

Other deposits similar to those just mentioned occur on Bald Creek in Yancey County. Also a large deposit of very dark green serpentine occurs near Cook Gap in Watauga County. These exposures are all far from means of transportation, and no exploratory work has been done at any of them. Consequently, they can at present be mentioned only as possible sources of serpentine.

WAKE COUNTY.

The serpentine of this County occurs along Barton Creek about 14 or 15 miles northwest of Raleigh. The rock is in the form of a dike of varying width, averaging possibly 250 feet. The dike in some places has been changed into soapstone and large masses of radiating green amphibole, probably actinolite, but for the most part the alteration has been into a dark to light yellowish-green serpentine. It contains many veinlets and granules of chromic iron ore, which vary greatly in amount present, sometimes occurring in great abundance and again rather sparingly. The stone, as is always the case with serpentine, is badly broken and jointed, but not to an extent that would prevent the quarrying of blocks of sufficient size for building purposes.

The exposures were found to be almost continuous, the width varying greatly from place to place, for a distance of nearly 2 miles. The texture and general character of the stone, except the color, which varies from dark to yellowish-green, appears to be fairly uniform throughout this entire distance. It does not, however, so far as observed, possess those qualities which are demanded of a high-grade decorative stone, the color generally being too dark and uninteresting for such purposes. But it is unquestionably of such character as to be of some value as a general building stone.

The stone occurs on the farms of Dr. A. J. J. Penny, Mr. Jesse Adams, and Mr. Joseph Tadlock respectively, and in many places on these farms, the exposures are of such a nature that quarries could be opened with little difficulty.

*Corundum and Peridotites of Western North Carolina, J. H. Pratt and J. V. Lewis, Vol. I, N. C. Geol. Survey, pp. 53, 399.

CHAPTER VI.

THE SANDSTONES AND QUARTZITES.

VARIETIES.

Under this head are grouped a widely varying series of rocks, having only in common the one property of being composed of more or less consolidated sands. They are made up of siliceous fragments derived from the disintegration of older crystalline rocks which have been rearranged through the mechanical action of water. The material by which the individual particles of a sandstone are bound together is, as a rule, of a calcareous, ferruginous (iron oxides), or siliceous nature, though sometimes argillaceous (clayey). The substance, whichever it may be, has been deposited between the granules by percolating water or during the process of original sedimentation and forms a natural cement. Upon the character of this cement is dependent, quite largely, the color of the stone and its working and lasting qualities, as will be noted later. Stones containing any considerable amount of ferruginous cement are nearly always of a yellow, brown, or red color. Several varieties of sandstone are popularly recognized, the distinctions being founded upon color or working qualities. Thus the name *brownstone* is applied to a sandstone containing so large a proportion of a ferruginous cement as to give it a brown or red color. The term *freestone* is given to any sand or limestone of sufficient uniformity of texture to work freely in any direction. The terms *calcareous*, *ferruginous*, *siliceous*, or *argillaceous* are often applied to sandstones in which these constituents play the role of cementing materials. Siliceous sandstones, which have undergone metamorphism like those near Hot Springs in Madison County, are known as quartzites. Many sandstones, owing to their laminated or thinly bedded structure, can be split out from the quarry only in the form of comparatively thin slabs, too thin for building purposes, but eminently suited for flagging. Such are often called *flagstone*, though the name is equally applicable to any stone thus used.

From a geological standpoint, the sandstones are known as Triassic, Carboniferous, or Silurian, etc., according to the period during which they were formed. According to the size and shape of their constituent

particles, they are known as sandstones proper, or, if the grains are large and rounded like a consolidated gravel, as conglomerate. When these large granules are angular instead of rounded, the stone is known as a breccia.

STRUCTURE.

The internal structure of the sandstones, as may readily be imagined, is quite variable. In some the particles are angular and in others they are rounded (see Fig. B, Pl. XXVII); at times the particles are of uniform size, or, again, they may be widely variable; at times closely compacted, or again, with a varying amount of interstitial space to be filled by cement. Most sandstones possess a more or less evidently laminated, banded, or bedded structure, due to the fact that they were laid down as sands or gravels on sea bottoms though this lamination is not always sufficiently pronounced to be visible in small blocks.

WEATHERING QUALITIES.

From the standpoint of durability (the power to resist atmospheric agencies), sandstones are the most variable of natural building materials, and with no class of stone is more judgment necessary in making selection than here. Some are capable of resisting, unharmed, for many years the most severe attacks of heat and frost; other succumb so readily as to be practically worthless. This wide variation is due, as may readily be imagined, to the equally wide variation in structure and composition. Sandstones which will absorb more than five per cent of water are liable to injury from freezing; hence the ratio-of-absorption test is an important one with this class of rocks. Moreover, many sandstones have a distinctly laminated structure. Such, when exposed in the walls of a building, particularly when placed on edge, are more likely to undergo exfoliation than those more massive. Sandstones in which the cementing material is calcareous are susceptible to the action of atmospheric waters, whereby the cement is removed, and the stone slowly disintegrates. Of all cementing materials the calcareous matter is most susceptible and the siliceous the least so, the ferruginous standing intermediate. Other things being equal, a purely siliceous sandstone (the siliceous granules being held together by a siliceous cement) is the most durable, though, unfortunately, the stones of this class are, as a rule, less desirable on account of color than are the ferruginous varieties. Many sandstones, and particularly the lighter varieties, such as are quarried from below the level of the ground water, contain iron pyrites, which oxidizes on ex-

posure, staining the rock either locally with unsightly blotches, or as causing it to take on a more uniform rust or cream tinted hue. Mechanical disintegration, either through a removal of the cementing matter or through the freezing of absorbed water, is the main cause of failure so common among stones of this class. The quartzites are, as a rule, less absorptive than are the sandstones and less affected by chemical agencies. Unfortunately, their poor colors and working qualities are something of a drawback to their very extensive use.

QUARRYING AND WORKING.

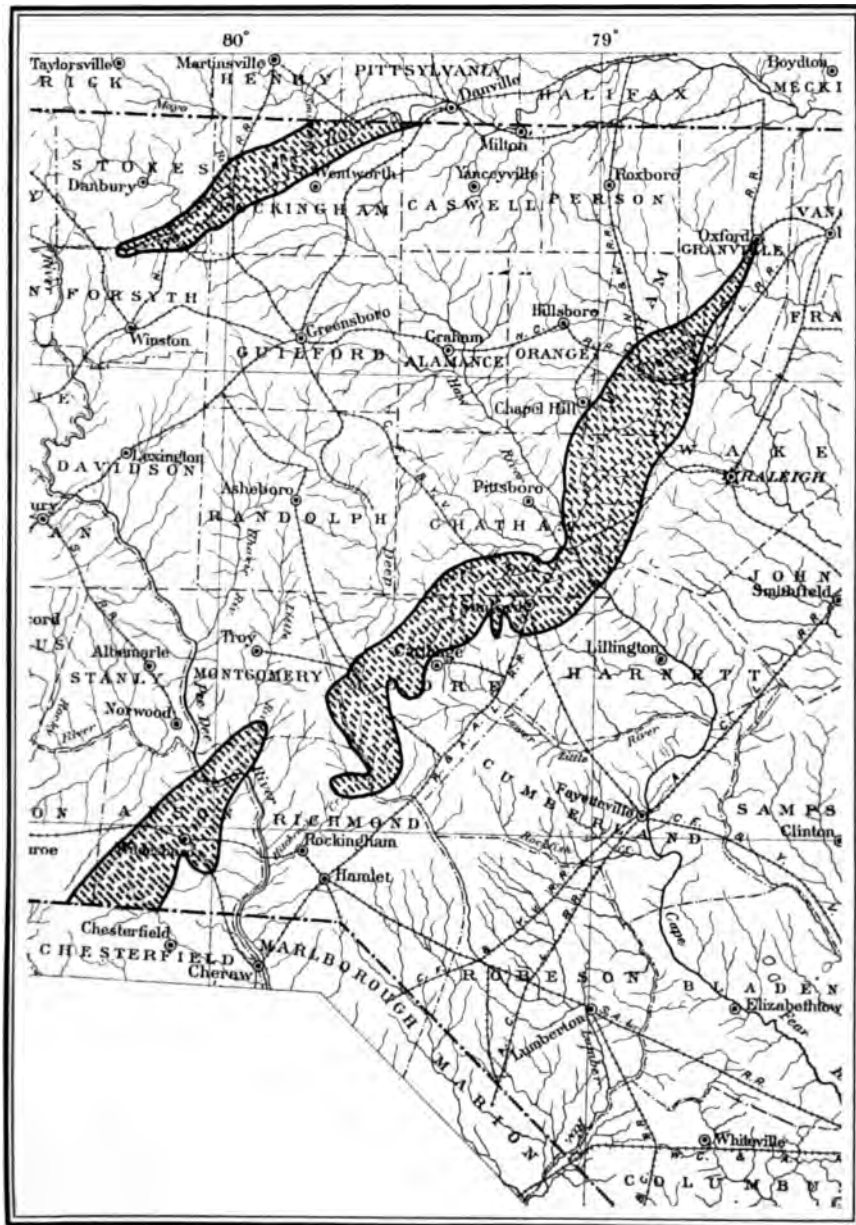
Sandstones occur in beds of varying thickness, once nearly horizontal, though they may now be inclined at varying angles. They are, as a rule, sufficiently soft to be quarried by the aid of channelling machines where the position of the beds will permit their use, and can be sawed with the ordinary reciprocating gang or diamond-toothed circular saws. They can also be worked with steam planers and tool-dressed in any desired form. Owing to their laminated structure, they split most readily along the plane of lamination, but in all the better qualities can be cut readily at right angles to this plane.

USES.

The sandstones are used almost wholly for exterior work, as in walls and steps of buildings, being, on account of color and texture, or lack of susceptibility to polish, quite unsuited for interior decoration, or for other than the more massive forms of monumental work. Owing to the ready working qualities of the freestone varieties, they are often elaborately carved, though it must be confessed that only too frequently the ability of the stone to withstand the rigors of our climate has been disregarded, the work crumbling to a condition quite the reverse of ornamental within a comparatively brief period. The variety of colors, the possibility of utilizing them in almost any sort of finish (from rock-dressed, through tool-dressed to sawed or sanded surfaces), and the cheapness with which such can be quarried and worked have long made the sandstones, as a whole, favorite materials for construction with architect as well as with builder.

GEOGRAPHICAL DISTRIBUTION.

The exploitation of the sandstones in the State is limited wholly to the Triassic beds, the distribution of which is shown in the accompanying map. These rocks, it should be noted, are the equivalent, geologically and lithologically, of the celebrated brownstones so generally used in



MAP OF CENTRAL PORTION OF NORTH CAROLINA SHOWING DISTRIBUTION OF THE TRIASSIC SANDSTONE.

New York and which have been quarried for many years in the Connecticut Valley, northern New Jersey, in Pennsylvania, in Maryland at Seneca Creek, and at Manassas in Virginia. The colors vary somewhat throughout the belt, but are as a rule, of a prevailing red-brown hue, rarely grayish brown (see Pl. XXIX).

As will be noted, the chief drawback to successful quarry development has, thus far, been the abundant jointing of the beds, whereby the stone is broken into polygonal blocks of comparatively small size. A lack of uniformity in color of the various beds has also proved a detriment. In the descriptions which follow, the quarries and outcrops are taken up and discussed systematically, beginning with the southernmost.

ANSON COUNTY.

WADESBORO AREA.

The Triassic sandstone extends across this County from the southwest to the northeast in a strip or belt of irregular boundaries, varying in width from 8 to 15 miles. The stone, for the most part, is covered by soil, but in many places, along streams and in railway cuts, good exposures are seen. The beds throughout the area are cut by three systems of joints, from a few inches to 25 or 50 feet apart, and trending usually from N. 30° to 60° W. and N. 60° to 30° E., and N. and S., those first mentioned seemingly being of greatest importance.

Cutting the sandstones always in the direction of a set of joints are a great many diabase dikes, varying in width from a few inches to several hundred feet. These dikes are nearly always vertical. A section across the sandstone beds from about a mile west of Lilesville, along the Seaboard Air Line Railway to near Polkton, a distance of perhaps 15 miles, shows over fifty of these dikes. And since the stone is not exposed for more than half the distance, it is possible that there may be in reality twice this number.¹

No systematic quarrying has been done in this County since 1890. However, one or two small openings are worked now and then to supply stone for local demand. Some of the most prominent openings and outcrops are as follows:

THE OLD LINEHAN QUARRY.

This opening is on the Jesse Edwards estate about 1¼ miles northwest of Wadesboro and only a short distance from the Seaboard Air Line Railway, with which it was once connected by a side-track. The opening is

¹ Bull. No. 85, U. S. Geol. Survey, p. 95.

in the northwest slope of a small hill and is drained by a small stream. The beds vary in thickness from 5 or 6 inches to as many feet and dip about 20° S. 35° E. The upper beds are variable in color and texture and are badly decomposed and worthless. Only one bed of any promise is exposed. It is the lowest and is about 6 feet in thickness. This bed is of a light red-brown color, uniformly fine-grained, but in some places contains small clay holes or "pockets." Its upper part shows a distinct tendency toward a shaly texture. This bed, as all the others, is broken by two prominent sets of joints—N. 30° W. and N. 60° E. Those of the first set are from 2 to 6 feet apart and of the second from 2 to 50 feet.

The fact that stripping now amounts to 12 or 15 feet, and must steadily increase as the work advances probably accounts for the quarry's being abandoned.

THE W. A. POLK QUARRY (FORMERLY THE WADESBORO BROWNSTONE COMPANY'S QUARRY).

This quarry, which has been abandoned for several years, is the one that furnished the "Wadesboro Brownstone," used quite extensively as a building stone in 1889 and 1890. The opening is about $1\frac{1}{2}$ miles northwest of Wadesboro and about one-fourth mile west of the opening just described.

Here, as in the old Linehan opening, there are two sets of joints, N. 60° E. and N. 30° W. The first indicated is the most prominent, the joints being from 1 to 7 feet apart. The others are from 5 to 25 feet. The beds dip approximately 25° S. 15° E.

The following vertical section of the stone exposed in the quarry face will give an idea of the succession of beds in this quarry.

1. a 15" Chocolate-brown, fine-grained.
- b 8" Light-brown, almost a gray, fine-grained.
- c 8" Red-brown, fine-grained.
- d 24" Dark or chocolate-brown, quite similar to "a."
- e 10" Light brown or gray, similar to "b."
- This bed is quite uniform in texture throughout.
2. 12" Badly decomposed, red-shaly material.
3. 18" Light brown, almost gray, similar to "1.b."
4. 8" Badly decomposed, red-shaly material.
5. 60" Light-brown, almost a gray.
6. 36" Badly decomposed, red-shaly material.
7. 48" Reddish-brown in color, with only a slight variation in texture. Clay pockets.
8. 12" Badly decomposed, shaly material.
9. 72" Light chocolate-brown in color, quite uniform, but varying considerably in texture. The lower 12 inches of this bed are very coarse, almost a fine conglomerate.

Beds 5, 7 and 9 are the only workable beds in the quarry.

From the above section it may be seen that this quarry has furnished stone of two colors—a red-brown and a light chocolate-brown. That of the last color is somewhat coarser in grain and freer from impurities than the red-brown stone, and is the bed that furnished the most desirable material. Stone from this quarry was used in the post office and Federal court buildings at Wilmington, Asheville, and Statesville; the Y. M. C. A. buildings in Charlotte and Atlanta, and in the Garrett school building in Baltimore (see Pl. XXX, B).

This stone consists of angular and sub-angular fragments of quartz and feldspar, biotite, much of which is altered to chlorite, cemented together with iron oxide, probably limonite. The quartz grains are clear when separated from the film or coating of iron oxide.

The chemical composition of the stone, as given by Dr. Merrill,³ is as follows:

Analysis of sandstone from Polk Quarry, Wadesboro, N. C.

	Per cent.
Silica	69.28
Alumina and iron oxides	13.84
Magnesia .....	.02
Potash and soda	6.43

FRANK HAMMOND'S QUARRY.

This consists of two small openings a short distance northeast of Rocky Ford Church on the White Store road, 2 miles southwest of Wadesboro. The openings are in the sides of two small hills on opposite sides of a small ravine.

The beds in each opening are from 1 to 4 feet thick and dip from 15 to 20 degrees S. 35° E. Joints in each opening are very prominent and quite close. They are of two sets of equal importance, trending N. 35° E. and N. 40° W. respectively, and varying from 3 to 4 inches to as many feet apart—usually about 2 feet. The beds vary in color from a reddish-brown to a light chocolate. The rock is uniformly medium fine-grained, and is free from clay partings and “pockets” and other defects. The stripping now amounts to from 6 to 10 feet and will increase since development must proceed in direction of the dip.

Along the east bank of Gould's Fork, 3 miles northwest of Wadesboro and about 200 yards northeast of where the Wadesboro-Ansonville road crosses the creek, is quite an extensive outcrop of light tan or buff colored

³ *Stones for Building and Decoration*, Geo. P. Merrill, 2d Ed., p. 472.

sandstone. This bed of stone has a thickness of from 6 to 7 feet and is exposed in the upper part of a steep slope along the creek for about one-quarter of a mile. The stone is apparently fairly uniform in color, but it varies in texture from fine-grained compact rock to coarse, more or less open-grained material—almost fine conglomerate. These coarse-grained areas, though not extensive, are distributed rather irregularly through the stone.

Joints are quite numerous, though not so close as to prevent the getting out of blocks of stone of almost any dimensions desired. They cut the beds as in previous instances N. 60° W., N. 30° E., and north and south. Their importance is in the order named. The beds are nearly horizontal, dipping very slightly southeast.

Stripping would be slight—from 2 to 4 feet—and, since the outcrop has so steep a slope—almost vertical in some places—a large quarry face could be easily opened.

W. PARSONS' QUARRY.

A small opening has been made about one-half a mile northwest of Wadesboro on a tract of land belonging to Wm. Parsons. Only one bed of workable stone has here been exposed. The bed is 7 or 8 feet thick, is covered by from 4 to 8 feet of soil and worthless rock, and dips about 15° S. 10° E. The stone is of medium fineness of grain, of a light chocolate color, of a slight reddish tinge, and is remarkably uniform in both texture and color. It is cut by two sets of joints of equal importance, trending N. 60° W. and N. 30° E. and from 2 to 15 feet apart—usually from 4 to 8 feet. This bed is unusually free from clay holes and other imperfections.

The opening is in the northwest slope of a small hill and work is advancing in the direction of the dip, thus causing the stripping to gradually increase in amount. The results of pressure tests on stone from this quarry are given on p. 236.

I. H. HORTON'S QUARRY.

About one-half mile south of the above described opening is another belonging to I. H. Horton. The opening has been made near the top of a small hill. Only one bed, about 6 or 8 feet thick, fine-grained and of a reddish-brown color, of workable stone has been exposed. This bed is neither uniform in color nor texture, is cut by two sets of joints, trending N. 60° W. and N. 30° E., respectively, and from 2 to 15 feet apart. It dips about 15° S. 15° E., and contains many irregular "clay pockets." Here also work in quarrying would advance in the direction of the dip, and the stripping would increase very rapidly.

There are a few more small openings in the vicinity of Wadesboro which have been worked as prospects and in some instances to supply stone for local purposes. There are also many natural exposures along streams, but the stone does not vary in any important characteristic from that of the openings and outcrops described. In fact, those described appear from the character of the stone or location with respect to facilities for transportation, to be the most important sandstones in Anson County.

MOORE COUNTY.

The Triassic formation extends across the County from southwest to the northeast. The belt varies in width from 5 to 18 miles and has a rather irregular outline. As in Anson County, the stone is quite closely jointed, joints having the same general trend as in that County. It is also cut by a great many trap (diabase) dikes. These dikes, while not quite so numerous as those of Anson County, are, as a rule, larger. They always follow one of the prominent sets of joints, the majority probably following the northwest set, and almost invariably cut the beds of sandstone at right angles to the bedding planes.

Considerable quarrying was at one time (in 1889-90) carried on in the northeastern part of the County, in the vicinity of Sanford. A great many places were prospected at that time and several quarries were opened, but in each case they were worked only a short time, and to-day a small quarry near Sanford is the only brownstone quarry in operation in the State.

CARTHAGE AREA.

Some of the most promising building stone in the whole Triassic formation of the State occurs near Carthage. No openings have, however, been made in this part of the County, and the observations upon which the following statements are based were made on natural outcrops.

The stone seems to be, as a rule, more heavily bedded than in other parts of the Triassic area. The beds vary in thickness from 1 to 10 feet and apparently average from 3 to 8. The color in the different beds varies from a distinctly red-brown to purplish-brown. The last is the prevailing color. The color of each bed is, for the most part, fairly uniform. The texture, while it varies from quite fine-grained to coarse conglomerate, is, as a rule, remarkably uniformly medium grained. The dip of the beds is from 5° to 15°, generally about 10°, in a southeast

direction. The jointing, while it has the same general directions, about northeast and northwest, is not quite so close as in other parts of the formation.

Details regarding some of the promising outcrops are as follows:

About three-quarters of a mile west of Carthage, on land belonging to A. H. McNeill, exposed in the banks and bed of a small stream, are several beds of stone, generally of one or two prevailing colors—a distinctly reddish-brown and a kind of gray chocolate-brown, the latter color being by far the prevailing shade. The various beds appear to differ slightly among themselves, but each bed, for the most part, seems to be quite uniform. There is some variation in texture or grain, but, as a rule, it is of medium fineness.

The beds dip slightly, about 5° or 6° southeast, and are from 2 to 8 feet thick. They are cut at right angles to the bedding planes by two sets of joints, trending N. 45° E. and N. 50° W., respectively. Those of the first set are the most prominent and are from 2 to 6 feet apart. Those of the second set are from 5 to 20 feet apart. Thus, it may be seen that, if a quarry face be opened parallel with the N. 45° E. joints, blocks of stone of almost any desired size may be obtained. Some prospecting with a core drill has been done at this place. The drilling extended to a depth of 45 feet. Some of the cores from the lower beds show practically the same color and texture of the upper beds. It is said that to the depth of the boring the grain is fairly uniform.

The stripping here would consist almost wholly of soil, possibly a small amount of rock, and would amount to 1 to 5 feet. It is probable the slope in some places is sufficient to afford natural drainage, but in other instances it is not, and a quarry, if opened, would have to be drained by pumping.

The outcrops occur at least a mile from the railroad, but the intervening country is level and a track could be run to them at minimum expense.

Stone quite similar to the above is outcropping in many places, on land belonging to Dr. H. B. Shields along a small branch of Killett's Creek from $\frac{3}{4}$ to $1\frac{1}{4}$ miles southwest of Carthage. It is probably of a somewhat more gray color than that on Mr. McNeill's land, and it seems to be slightly coarser in texture.

The beds are from 2 to 6 feet thick and dip about 10° S. 35° E. The jointing here, as at the other place, is of two sets, N. 30° to 40° E. and N. 20° to 35° W. The northeast set is fairly close, from 1 to 15 feet apart, averaging from 4 to 8. Those of the other set are from 2

to 60 feet and average perhaps 6 to 12. Stripping would vary from 1 to 10 feet, according to locality.

There are frequent large exposures of sandstone along McLendon's Creek, from 12 miles southwest of Carthage to where the creek flows into Deep River about 15 miles north of Carthage. In many places the color, texture, amount of overlying worthless rock and soil, the dip or the closeness of the jointing, or some combination of these, renders the stone worthless. However, in a few localities outcrops of a fairly promising character may be seen.

For about a mile above the bridge, where the old Plank wagon road crosses this creek, are some of the most favorable exposures on the creek. The rock here forms a ridge from 50 to 100 feet high, which slopes very abruptly up from the east bank of the creek, and it is in this steep slope that the most promising stone is showing. The beds vary in color from a decidedly red-brown, almost a brick-red, to a distinctly chocolate brown. The color for the most part is uniform throughout the same bed, though the different beds vary more or less. They dip about 10° S. 60° E. and are cut, as usual, by three sets of joints, N. 30° E., N. 30° W., and north and south. The first two sets are of the most prominent and are of about equal importance, being from 2 to 8 feet apart, usually from 4 to 6. The third set, while well developed in some instances, is generally of little importance. The texture or grain varies but slightly, being from fine to medium.

The amount of stripping would not be very heavy, as a rule. The form of the outcrops, the proximity to the creek, which could easily be made to furnish ample power for sawing the stone, and which would probably furnish sufficient power for operating the whole quarry, and the facilities for disposing of waste material, render some of these outcrops most favorable for quarrying. Some of the above-mentioned outcrops are on land belonging to D. A. McDonald, and others are on that of George Stead.

Stone for use in the Moore County court-house was obtained from a small opening on Mr. Stead's land, about 3½ miles northwest of Carthage. The opening has been abandoned and is now filled with water, but many blocks on the edge of the old quarry show the stone to be of a remarkably uniform, dark reddish-brown color and fairly fine-grained.

The dip is slight, the beds lying almost flat, and the jointing, as far as could be determined, quite the same as at the exposures along McLendon's Creek. The stripping is slight and consists almost wholly of soil.

Many outcrops of stone, usually of a chocolate color, occur along a

small branch of McLendon's Creek about $1\frac{1}{2}$ to 2 miles northwest of Carthage, on land belonging to Thomas Cole. Both color and texture appear to be fairly uniform. The beds vary in thickness from 1 to 6 feet and dip from 10° to 20° S., 50° to 60° E. The joints are, for the most part, of two sets, N. 15° or 20° E. and N. 60° W. and are from 1 to 6 feet apart. Some places, however, show 3 or even 4 sets of joints, the minor sets trending N. 65° E. and east and west.

Along Deep River, which flows for several miles across the Triassic formation in the northern part of Moore County, are many outcrops of sandstone, varying in color from an olive buff to reddish chocolate brown, and in texture from very fine-grained sandstone to fine conglomerate. The outcrops along the river and its tributaries—Crowley's Creek, Governor's Creek, and some other smaller streams—are generally in the form of bluffs or very abrupt slopes, varying in height from 30 to possibly 140 feet. As a rule, each bed is more or less homogenous, but the separate beds differ very much in texture and color. In nearly every outcrop one or more thin strata of red shaly material occurs. The other beds may be either massive and uniform in both texture and color or they may be made up of thin "shelly" layers and vary greatly in color and texture.

The dip here is greater than in the vicinity of Carthage, averaging about 15° S. 30° E. Joints are generally of two sets, trending on the average N. 30° W. and N. 60° E., and from 1 to 8 feet apart. They cut the strata at about right angles to the bedding planes. In many places they are so numerous that the stone is worthless, but in a few places outcrops may be seen free enough from joints to be quarried profitably, other things being favorable.

Some of the most favorable outcrops of this locality occur along Crowley Creek, on land belonging to J. L. Knight of Glendon. The beds of stone are exposed in either very abrupt slopes or bluffs along the creek and are from 30 to 100 feet high. They dip 15° S. $30 \pm$ E. and are cut by joints running N. 30° W. and N. 60° E. and from 1 to 10 feet apart. Two beds of rather uniform fine-grain, one of a leather-red color, the other of reddish chocolate-brown, each probably 6 or 7 feet thick, separated by a thin bed of red shaly material, constitute the favorable stone of this exposure. These beds are near the top of the slope, and there are about 75 feet of unexposed slope below them which may also contain even better beds.

Everything here is favorable for quarrying except the distance from the railroad (about 4 miles) and the all but impassable country roads. These last two conditions render the stone inaccessible at present.

THE SANFORD AREA.

THE CARRINGTON-GONELLA QUARRY.

In the northeastern part of this County, near Sanford, were located the most important quarries that ever were operated in the brownstone area of the State. These have, for the most part, long since ceased operations. It is also here that we find the only sandstone quarry in actual operation in the State to-day, the Carrington-Gonella quarry, $1\frac{1}{2}$ miles south of Sanford.

The stone here is apparently in no way superior to that occurring in other places in the County, and, indeed, the natural outcrops are less favorable to quarry development. The reason for the development here is probably the nearness to the railroad.

The Carrington and Gonella quarry is located about $1\frac{1}{2}$ miles south of Sanford and about 200 yards west of the Seaboard Air Line Railway. The opening is located near a little ravine in the southwestern slope of a low-lying hill, and is about 100 x 110 feet and 12 or 15 feet deep, being drained by a small pump (see Pl. XXX, A).

Only one bed of workable stone has been exposed. This is 6 or 7 feet thick, dips slightly 40° or 50° W., and is of two distinct colors—a red and a grayish chocolate-brown. The upper two or three feet of the bed are of the first color, the remaining four or five feet of the brown shade. These colors are quite uniform, but gradually shade into each other. The red stone seems to be of a finer grain and to contain more clayey material than the brown. The texture of both varieties is fairly uniform, although there are a few small rounded pebbles seen here and there. This is especially true of the lower part of the brown portion of the bed, which, indeed, is directly overlying a 7 or 8 foot bed of conglomerate.

There are two principal sets of joints, N. $60^{\circ} \pm$ W. and N. 30° E., and a third set east and west of slight importance. The important sets are from 2 to 15 feet apart—usually from 4 to 8.

The stripping is so heavy on the north side of the opening that work cannot advance farther in that direction. On the west and south sides, the direction in which the work is advancing, it varies from 1 to 7 feet and, for the most part, consists only of soil.

The quarry was opened in 1900 and has been operated continuously ever since. The working force, including stone cutters, is about 12 men. Stone is dressed at the quarry and hauled on wagons about 200 yards to a small spur of the railroad and is there loaded on the cars. The quarry is equipped with the following machinery: One 11 ft. gang saw; one 30 h. p. boiler; one 25 h. p. engine; one quarry bar; one I. & S. steam drill; one 10 ton double drum hoist.

Stone from this quarry has been used in the following buildings: Harrison Building, Augusta, Ga.; Masonic Temple, Wilmington; A. & M. College, Raleigh; Union Theological Seminary, Richmond, Va.; Government Building, Newbern; the First Baptist Church, Spartanburg, S. C.; and in several other less important buildings.

Crushing tests made at the Watertown Arsenal showed a strength of 10,800 lbs. per square inch.

There are a great many outcrops in roadsides and along streams northwest, west, and southwest of Sanford. At a few of the most promising of these some prospecting has been done, but apparently nothing of much value has been found. These outcrops are quite similar in nearly every feature and a description of one of them would, with very slight modification, be applicable to any other. Hence, it is deemed unnecessary to describe more than one.

The place thus selected is located on D. N. McIver's land about three-fourths of a mile northwest of Sanford. Here, in the side of a small hill, immediately north of a small stream, a prospect opening has been made. Two beds, the thickest of which is perhaps 6 feet, are exposed. They dip about 10° S. 30° W. and are broken by two sets of joints at right angles to the bedding planes of the strata from 1 to 6 feet apart and trending N. $60^{\circ} \pm$ W. and N. 30° E., respectively. The color of the stone is a very pretty reddish-brown and the grain is apparently uniformly fine. The upper bed contains numerous clay "pockets," but the lower is nearly, if not quite, free from them. The color of this bed is somewhat darker than that of the upper, and is remarkably uniform. The stripping is slight and consists principally of soil. The slope in which the opening was made affords natural drainage.

Several places where quarries were formerly in operation, but are now abandoned, were visited. The first of these was an opening about 200 yards north of the Southern Railway about $1\frac{1}{2}$ miles northwest of Sanford. This place was once the site of the Carolina Brown Stone Company's quarry. Only one bed of workable stone that varies more or less in color and very much in texture, is exposed. Stripping was heavy and the beds were broken by three quite prominent sets of joints, 2 to 8 feet apart and trending N. $35^{\circ} \pm$ W., N. $45^{\circ} \pm$ E., and E. and W. The beds dip approximately 12° S. 10° E. There is no way of draining the opening except by pumping and also no place for disposal of waste.

THE BACKLE AND LAWRENCE QUARRY.

The opening, located about $1\frac{1}{4}$ miles south of Sanford, is now a pond of stagnant water, and no stone could be seen in place, but blocks piled



A. THE CARRINGTON-GONELLA SANDSTONE QUARRY NEAR SANDFORD, N. C.



B. POST OFFICE BUILDING, WILMINGTON, N. C. BUILT OF SANDSTONE FROM NEAR WADESBORO,
ANSON COUNTY.

Stone from this quarry has been used in the following buildings: Harrison Building, Augusta, Ga.; Masonic Temple, Wilmington; A. & M. College, Raleigh; Union Theological Seminary, Richmond, Va.; Government Building, Newbern; the First Baptist Church, Spartanburg, S. C.; and in several other less important buildings.

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Several places where quarries were formerly in operation, but are now abandoned, were visited. The first of these was an opening about 200 yards north of the Southern Railway about $1\frac{1}{2}$ miles northwest of Sanford. This place was once the site of the Carolina Brown Stone Company's quarry. Only one bed of workable stone that varies more or less in color and very much in texture, is exposed. Stripping was heavy and the beds were broken by three quite prominent sets of joints, 2 to 8 feet apart and trending N. $35^{\circ} \pm$ W., N. $45^{\circ} \pm$ E., and E. and W. The beds dip approximately 12° S. 10° E. There is no way of draining the opening except by pumping and also no place for disposal of waste.

THE RACKLE AND LAWRENCE QUARRY.

The opening, located about $1\frac{1}{4}$ miles south of Sanford, is now a pond of stagnant water, and no stone could be seen in place, but blocks piled



A. THE CARRINGTON-GONELLA SANDSTONE QUARRY NEAR SANDFORD, N. C.



B. POST OFFICE BUILDING, WILMINGTON, N. C. BUILT OF SANDSTONE FROM NEAR WADESBORO,
ANSON COUNTY.

up on the edge of the pond show that the material is uniform in neither color nor texture. The texture varies from fine, even-grained sandstone to fine conglomerate. Many of the blocks also show numerous clay holes. The surrounding rocks dip perhaps 15° N. 60° W. and are cut by two sets of very close joints, trending N. 60° W. and N. 30° E. Stripping was also very heavy, and there was no means of draining the opening, except by pumping.

CHATHAM COUNTY.

The Triassic extends across the southern and eastern portion as a strip varying in width from 6 to 8 miles to 12 or 18 miles. Its general features do not differ from those of the same formation in the other counties. The stone may be seen outcropping along Deep River and the small streams that flow into it, also along a portion of the Haw River and along Hope River, which flows over its beds for a distance of about 20 miles. The formation here is also cut by numerous diabase dikes which always follow one or the other set of joints. The sandstone in this County does not differ essentially in either color, texture, or structure from that of Moore County. Thus, what has been said about the stone in that County will, with practically no modification, be applicable to this.

No quarries are now in operation in this County, but it seems best to describe one or two places where more or less work has been done.

An opening was made several years ago on the east bank of Deep River, about $1\frac{1}{2}$ miles southeast of Gulf. Considerable work has been done here and more or less machinery is now at the place, but it has evidently been abandoned for several years. The opening is made in a slope rising rather abruptly about 25 feet above the river. Only one bed of anything like workable stone is exposed. It is of a variable buff or yellowish-gray color, in places almost white, is probably 7 or 8 feet thick, is fairly massive, and dips 15° S. 60° E. The texture of the stone is rather coarse and is somewhat variable. This bed is remarkably free from joints, having only one prominent set, not close, trending N. 30° W., and another subordinate set running N. $35^{\circ} \pm$ E. The stripping amounts to from 8 to 15 feet and consists of both soil and worthless stone. The work would necessarily advance in the direction of the dip, thus causing the stripping to increase very rapidly. The opening is, unfortunately, located so near the river that during freshets the whole place is overflowed.

In many other places along Deep River and the small streams that flow into it, outcrops of the usual red and chocolate-colored sandstone

may be seen. The beds, in some instances, are fairly uniform in color and texture, while, in others, there is much variation in both. Some of the beds thus exposed are so located that the stripping would be very light, but in practically every instance the beds dip so steeply that the stripping would increase rapidly from the start and soon become so heavy that it could not be economically removed. In some cases the joints, which, as a rule, are from 2 to 10 feet apart, are such that blocks of workable dimensions might be obtained, while in others they are so close that the stone is worthless. If exploitation should show up stone of such a character along this river as to warrant quarrying, the stone could be readily and cheaply taken to shipping points by means of barges. This fact renders much of the Triassic area that could not be otherwise reached quite accessible.

A small opening has been made in the east bank of Deep River, about three-fourths of a mile northwest of Cumnock (formerly Egypt), on the Southern Railway. The opening is in a very steep slope, almost a bluff, about 25 feet high. Only one bed of workable stone is exposed. This is of a fairly uniform red-brown color, and of fine, even grain. It does, however, generally show very slight stratification lines—so fine that they are not discernible except upon the closest scrutiny. There are also a few small clay holes in the upper portion of the bed, but they seem to be confined to the upper 8 or 10 inches, as none were seen in the middle or lower portions. This bed dips 10° S. 10° E. and is cut by three sets of vertical joints, trending N. 45° E., east and west, and north and south, and varying from 4 to 15 feet apart. The last mentioned set is not very well developed and is of little importance. Stripping would amount to from 4 to 10 feet, and would increase as work would proceed, since it must advance in the direction of the dip of the strata.

The best grade of stone from this opening weathers well. In a small cemetery near the opening are a few headstones made from it, which though exposed to the weather for years, still show no signs of disintegration.

In other places near this one, especially in some small cuts on the Chatham Coal and Iron Company's railroad, east of Cumnock, are exposures of similar stone. What has been said about the above opening is, with practically no modification, applicable to any one or all of them.

ORANGE COUNTY.

Only a very small area of the Triassic is within this County. This is in the extreme southeastern corner.

Though the stone is outcropping in several places along a small trib-

utary of Hope River, no exposures of sufficient importance to warrant quarrying were seen, the stone not being uniform in either color or texture. It is also so badly jointed as to condemn it, even were other qualities satisfactory.

In only one place within the County has any quarrying been done. The opening is located about $1\frac{1}{2}$ miles southeast of Chapel Hill and was made over a century ago in order to get stone for use in the buildings of the State University, and hence is known as the "University Quarry." The beds are from 4 to 6 feet thick, of a fairly uniform purplish gray color, but of variable texture. It is cut by four distinct sets of vertical joints, from 2 to 10 feet apart and trending north and south, east and west, N. 30° W., and N. 60° E. respectively. The first two sets are most prominent, the others being of small importance. The peculiar color of the stone is doubtless due to the influence of a large diabase dike following the north and south joints only a few feet from the opening.

WAKE COUNTY.

The sandstone formation extends entirely across the western part of this County, but nothing in the way of systematic quarrying has ever been attempted and, in fact, very little prospecting or exploratory work has been done. The stone does not differ in any important particular from that of the other counties that include Triassic areas.

Many outcrops were visited and the general features of the stone were found to be so uniform that it is thought necessary to include descriptions of but two or three places that appear to be typical.

On a farm belonging to W. C. Young, $2\frac{1}{2}$ miles northwest of Morrisville is a large exposure of sandstone from which stone for foundations, chimneys, etc., has been taken. The stone exposed is in beds from a few inches to probably 5 feet in thickness, the upper layers of which are badly weathered and more or less shaly. The fresh beds are fairly uniform in texture, generally fine-grained, but are of two distinct colors—a reddish-brown and a kind of chocolate-brown. The beds dip from 7° to 10° S. 60° E. There are, as usual, three distinct sets of joints, N. 60° W., N. 45° E., and north and south, so close together that it would be impossible to get out dimension stone. In addition, all the stone exposed has been badly mashed and sheared; nearly every joint plane shows more or less slickensiding.

About $1\frac{1}{2}$ miles west of the above place, on land belonging to W. M. Howard is an outcrop, the best bed of which is perhaps 5 feet thick. The texture is from medium grain to fine conglomerate, the conglomerate being the lower 6 or 8 inches of the bed. The red-brown color is here and

there marked with purplish gray streaks. There are but two series of joints, from 2 to 10 feet apart and trending N. 30° W. and N. 60° E. respectively. The outcrop is in the west side of a small hill or ridge that slopes gradually upward from a small branch in the bed of which similar stone is exposed for some distance both above and below the outcrop described.

DURHAM COUNTY.

By referring to the map (Pl. XXIX), it may be seen that practically the southeast half of this County is of the Triassic formation. The rocks here are closely jointed, probably more so than in any other county, there being always two well-defined series of joints, usually three, and sometimes four. The beds vary in thickness from a few inches to 8 or 10 feet, and dip, usually about 10°, in a southeasterly direction. The texture of the sandstone is possibly a little more uniform than elsewhere, but the color is variable, being from almost a grayish flesh-color or grayish pink to a distinct purplish chocolate-brown.

Excepting that of Anson County, the Triassic of this county contains more and larger diabase dikes than any other county in the State. These dikes always follow a set of joints, generally a northwest, though quite frequently a northeast set. They vary from a few inches to over 500 feet in width.

No systematic quarrying has ever been done in this county, but here and there small openings have been made to supply stone for local uses. Some of these and some of the natural outcrops that may be considered typical will be described.

On A. Rigsby's land, about a quarter of a mile southwest of Brassfield, is quite an extensive outcrop of sandstone of a light chocolate color, forming a large bluff along the east side of Goose Creek. The color and texture are fairly uniform in the same bed, but vary somewhat in the different beds. The beds exposed are from 2 to 6 feet thick and are cut by two sets of vertical joints trending N. 30° E. and N. 30° W., respectively, from 1 to 10 feet apart. The amount of stripping, consisting of both soil and worthless rock, would be between 4 and 8 feet at the beginning, but would increase rapidly, since the work would have to advance into the hill and also in the direction of the dip, which, however, is slight, about 5°.

Some work has been done here in order to secure stone for local uses, but nothing in the way of systematic quarrying has been attempted, and it has apparently been several years since the last work was done.

A few paces west of the above outcrop, just across the creek, is a small

opening made years ago to get stone for buildings at Raleigh. Only one bed of workable stone, about 6 feet thick, is exposed. This bed is a compact, even-grained stone, of a fairly uniform grayish pink or flesh color, containing considerable mica (muscovite). The joints here, while having the same trend as those of the opening just described, are, on the average, farther apart. The stone also appears to lie practically horizontal. The stripping, too, is slight, 3 to 5 feet, and consists almost entirely of soil. The opening is in the narrow creek valley and is only slightly, if any, above the level of the stream bed. Thus, considerable trouble from water might be expected if the stone should ever be quarried at this point.

There are several other outcrops of sandstone along this creek similar in practically every respect to those just described. The jointing, while always close, is apparently, in some places such that dimension stone could be obtained, if other features should be favorable. However, in every place, the joints are close enough to be considered a serious defect of the stone, and in many instances they render it absolutely worthless.

Some openings were made near Durham years ago to supply stone for foundations, trimmings, etc., for local use. The most prominent of these, while hardly more than prospect openings, are spoken of as quarries. They are the Robt. I. Rogers' Quarry and Duke's Quarry, and are located $1\frac{1}{2}$ or 2 miles east of Durham.

The Robt. I. Rogers' Quarry is an old opening which has been made in the base of a low-lying hill about 2 miles east of Durham. Only one bed of stone was worked. It is about 5 feet thick, is fairly uniform in texture, is cut by four sets of quite prominent joints trending N. 15° E., N. 65° W., N. 55° E., and east and west (the N. 15° E. set from 1 to 3 feet apart, others from 5 to 12), and dips about 10° E. The color is from a pinkish brown to a decided chocolate brown. Stripping, from 6 to 10 feet at present, but would increase rapidly, since work must advance in the direction of the dip.

Duke's Quarry is located about $2\frac{1}{2}$ miles northeast of Durham. The beds that were worked here are somewhat thicker than those above described; perhaps from 7 to 8 feet. The rock is also similar in texture and color, except that this stone is somewhat darker, more of a purplish hue, and is not so uniform. The joints are the same as those of the Rogers' opening, having exactly the same trend, except that the east and west set is apparently not developed. Dip is 10° E. Stripping amounts to from 7 to 10 feet now and must increase very materially as work might proceed, for reasons already noted.

STOKES AND ROCKINGHAM COUNTIES.

It will be seen by referring to the map, Pl. XXIX, that a large area of Triassic sandstone is indicated as occurring in the Dan River valley in Stokes and Rockingham counties. This area of Triassic rocks is first met with near Germanton, a station on the Southern Railway. It extends from this point as a narrow belt varying in width from 3 to 5 miles, northeastwardly to the North Carolina-Virginia boundary line, a distance of about 100 miles.

The beds of stone dip rather steeply toward the northwest, probably 30° to 50° , and are cut by two to four sets of very closely spaced joints. They vary greatly in both color and texture. The former variation is from almost black through many shades of brown to a rust-like red, there being apparently no regularity whatever in regard to color. In texture the beds vary from a nearly typical carbonaceous shale, coal-bearing in places, through impure sandstones of varying fineness into a typical coarse conglomerate. In thickness the beds also vary greatly from only a few inches to many feet. These features make it quite certain that this area contains no stone that could be quarried for any but purely local use and then only for the lowest class of work, such as culverts, bridge piers and in the construction of dams. Only a few small openings have been made, and these were to secure a rock for some of the purposes just mentioned.

This Triassic area, like the large area lying to the east, is cut by numerous diabase dikes, many of which are very large and will furnish vast quantities of excellent road metal. The limited amount of time available for field study in this section made it possible to visit only a few of the most important of these dikes, see p. 237.

TESTS ON SANFORD AND WADESBORO SANDSTONES.³

It has long been known that clastic rocks, that is, rocks of the nature of sandstones, of high absorptive power, undergo a loss of strength through the absorption of water, and at times an additional loss through freezing when in a saturated condition. Of recent tests along these lines, those of Prof. Anson Marston, of the State Agricultural College of Iowa, are of greatest importance so far as the present writer has information.⁴ The results obtained by Prof. Marston were of so striking a

³ These tests were made by or under the direct supervision of Mr. Laney.

⁴ See Proc. 10th Ann. Meeting of the Iowa Engineering Society, Jan., 1898, pp. 123-136.

nature, it was thought worth while to repeat the tests in part on North Carolina materials. The facts obtained, and as given below, fully substantiate those obtained by Prof. Marston.

A series of twelve accurately prepared 2-inch cubes of sandstone, from Sanford and Wadesboro, were selected, six from each source. From each series two were crushed dry, two when saturated with water and two after soaking in water and then being frozen. Incidentally the specific gravity and weight per cubic foot were obtained.

To secure saturation and at the same time ascertain the specific gravity, two cubes from each locality were first dried to a constant weight; they were then immersed in distilled water for 48 hours, at the end of which time the air was exhausted from the pores of the stone until a vacuum of 9 inches was obtained. Under these conditions the cubes were allowed to remain for another 48 hours, when they were removed, weighed in distilled water, and the specific gravity calculated by the ordinary method. The results are given in the table on p. 236. These same cubes were used, in their saturated condition, for pressure tests, and showed a decided weakening as noted later.

For the freezing tests, four more cubes of precisely the same nature were selected and placed first in a pan of distilled water, where they were allowed to soak for 72 hours. They were then removed and quickly weighed, after wiping from the surface the excess of water by bibulous paper. They were then placed in a basin containing a small amount of water and subjected to ten alternate freezings and thawings, the freezing process being carried on in the cold storage rooms of the Washington Market, where a temperature of from 5° above to 6° below zero F. prevailed. The figures below show the loss in weight of the cubes through the forcing off of small particles by the expansive power of the water when passing into the condition of ice. The results, it will be noted, are very slight.

Freezing Test on 2-Inch Cubes of Sandstone.

Number of cube.	Weight before freezing.	Weight after freezing.	Loss.
5.	325.73 grams.	324.995	0.735
6.	320.86 "	320.52	0.34
11.	323.55 "	322.89	0.66
12.	326.85 "	326.135	0.71

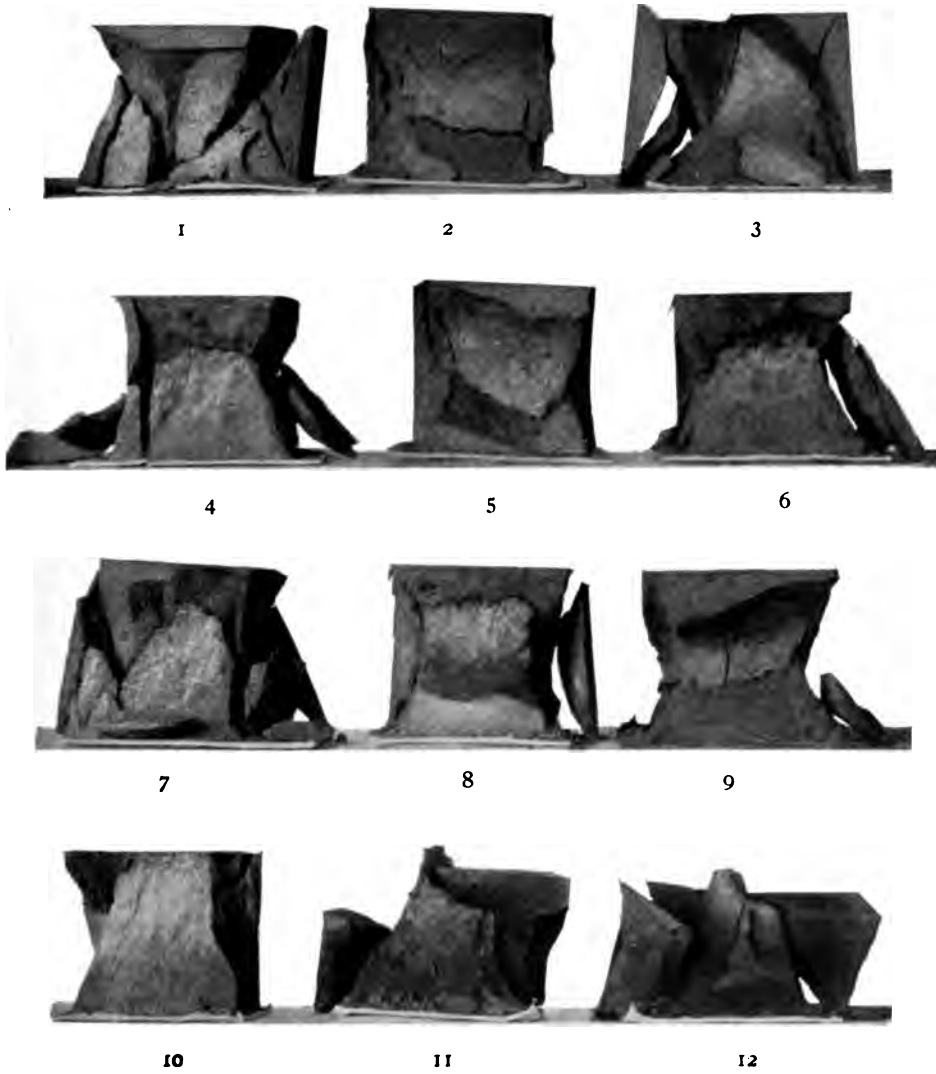
After the tenth freezing and thawing, and the weighings, above noted, the cubes still full of water were submitted to the same crushing tests

as the others. The results of these tests are given in the following table.

Crushing Tests on 2-Inch Cubes of Sandstone, Dry, Wet and After Freezing.

Number of cube.	Specific Gravity.	Wt. per cu. ft.	Absorption.	Condition.	Crushing Load.	Strength per sq. in.	Remarks.
1.	2.635 2.645	163.6	4.20	Dry.	41,290	10,322	Failed gradually.
2.				"	44,800	11,150	" "
3.				Wet.	27,850	6,932	Burst in pieces.
4.				"	23,850	5,937	Failed gradually.
5.				After freezing.	26,500	6,625	" "
6.				"	27,500	6,875	" "
7.	2.625 2.625	162.7	3.71	Dry.	49,000	12,250	Failed suddenly.
8.				"	45,330	11,232	" "
9.				Wet.	22,550	5,637	Failed gradually.
10.				"	26,850	6,712	" "
11.				After freezing.	25,150	6,287	" "
12.				"	26,000	6,500	" "

The results shown in the above table somewhat exceeded expectations so far as related to loss of strength by saturating with water only, but the loss by freezing was not as great as was expected. Indeed, as will be noted, the cube that had been frozen is in some cases stronger than the corresponding one that had been simply saturated. The difference is, however, slight and the number of tests too few to permit the deduction of anything of value. The very great loss in strength, averaging upwards of 44 per cent by simple saturation with water, is, however, a very important matter and one that should receive serious consideration whenever stone is to be placed in a position like a foundation for bridge abutment. It should be noted, however, that a strength of even 6,000 lbs. per square inch is sufficient for ordinary construction. It was noteworthy in the tests that the dry cubes for the most part failed suddenly, while the wet simply yielded slowly and gradually (see Pl. XXXI).



FORMS ASSUMED BY 2-INCH CUBES OF SANDSTONE AFTER SUBJECTION TO CRUSHING TEST.

CHAPTER VII.

DIKES PENETRATING THE SANDSTONES.

One of the most striking features of the Triassic areas of the State is the great number of dikes of igneous rocks which penetrate the sandstones. These dikes are scattered throughout the whole formation, more or less irregularly of course, in such numbers that no considerable district was found in which they do not occur. But they are much more numerous in some localities than in others. For example, in Anson County, a section across the sandstone along the Seaboard Air Line Railway, from near Lilesville westward to near Polkton, a distance of about 15 miles, shows no less than 50 dikes varying in size from a few inches to over 100 feet.¹ Since for more than half the distance the railroad made no cuts or was constructed by making fills, thus not uncovering the rocks or covering them still deeper for the greater part of this distance, it is safe to assume that at least 100 dikes would be showing in this distance of 15 miles, if the rock were exposed throughout the whole distance. An example of the other extreme is found near Sanford in Moore County, where a section of nearly 4 miles fails to show a single dike.

There are two principal systems of joints developed in the rocks of this area, averaging N. 35° or 40° W. and N. 45°-65° E., generally approximating N. 30° W. and N. 60° E. In addition to these, there are two subordinate systems trending north and south and east and west respectively.

The dikes *invariably* follow one or the other of these joint systems, in the majority of cases a northwest set. Out of 44 important dikes that were carefully measured, 27 had a northwest trend, 10 were trending northeast, and the remaining 7 had an approximately north and south trend.²

At many of the dikes, especially in Anson County, where railroad cuts have given good exposures of both country-rock and dike, there occur sudden changes of dip of the sandstone beds adjacent to the dikes, thus

¹ I. C. Russell, Bull. No. 85, U. S. Geol. Survey, pp. 94-95.

² For trends of joints and dikes of the Triassic area, see pp. 241-243, and for the other areas, see pp. 184-186.

indicating that the igneous material was extruded along displacements. Faulting of the sandstone beds throughout the whole Triassic area is apparently quite common.*

The dike material is always, as far as determined, a typical diabase, generally, rich in olivine. Sometimes the rock is fine-grained, especially in the narrow dikes, while again, in the large ones, the grain may be medium or quite coarse. Also each dike of any considerable size always shows a very fine-grained area at the contacts with the country-rock, where the magma would be cooled most rapidly, and an interior of much coarser grain.

In the following notes, only those dikes are mentioned in detail which are large enough to be of more or less economic importance.

ANSON COUNTY.

In the western limits of the town of Wadesboro, near a negro church, a dike more than 100 feet wide is in evidence.

About 1 mile north of Wadesboro and only a short distance from the Seaboard Air Line Railway are two large and very favorably situated dikes, each about 125 feet wide. One is exposed in the north end of the old Linehan quarry excavation, and the other is about 300 yards east of it. These dikes are so located that they will furnish a great deal of excellent road metal.

At Brown's Creek, about $7\frac{1}{2}$ miles northwest of Wadesboro is a diabase dike over 500 feet wide. This is probably one of the largest dikes in the whole Triassic area of the State. This dike, although it is deeply weathered, will furnish a vast quantity of good road material. Results of tests of this rock for road material are given on p. 265.

On Jones' Creek in the southeastern part of the County is a large dike of trap rock (hypersthene gabbro) that will furnish a great amount of road metal practically as good as that of the diabase dikes. This dike is probably a continuation of the gabbro dike near Steele's Cotton Mill in the western part of Richmond County.

CHATHAM COUNTY.

Only one dike was seen in this county of sufficient size to be of economic importance. This one, a typical diabase, occurs about 200 yards southeast of the railway station at Gulf. It has a width of about 200 feet, but is so deeply weathered that no estimate of the available road material can be given. Other dikes are exposed at several places along the Seaboard Air Line Railway, between Sanford and Merry Oaks, a few of which are apparently large enough to be of some value.

* I. C. Russell, Bull. No. 85, U. S. Geol. Survey, p. 94.

DURHAM COUNTY.

Only a very little time was spent in examining the supply of road material of this County, and consequently but a very few of the largest and most easily accessible dikes were visited. The County apparently contains as much trap rock as any other of the Triassic counties of the State, but as a rule the dikes seem to be small.

The following are some of the dikes that are considered large enough to be of economic value.

The Southern Railway crosses a deeply weathered diabase dike over 500 feet wide, about 3 miles northwest of Durham. This dike will furnish a vast deal of excellent road metal.

The Durham-Raleigh wagon road, running southeast from Durham, crosses several dikes, three of which having each a width of over 100 feet and located 2, 2½ and 6 miles southeast of Durham, are probably worth mentioning. Practically all the available surface material from these dikes has been used and the dikes are so deeply weathered that no reliable estimate of the material they will furnish can be made.

MOORE COUNTY.

The dikes of this County are quite numerous and also, as a rule, are large. The following list of a few of the largest and most promising dikes gives the location of some of the best road metal in the County.

On the old "Stage" road, near a negro church, about 3 miles west of Carthage is a 75 foot dike of typical diabase.

Near Kelley's old mill on McLendon's Creek about 3½ miles northwest of Carthage is a very promising dike 125 feet wide. This dike is apparently in fair condition as regards weathering, and it will, with no great amount of labor and expense, furnish a vast amount of excellent stone.

About a quarter mile south of the old "Stage" road, 8 miles southwest of Carthage, there is a diabase dike probably 250 feet wide. It extends across the country for some distance as a low ridge, and while only a few boulders are to be seen on the surface, it is probable that a little exploratory work will reveal a great amount of excellent road metal.

Near Black's old mill on Little River, about 7 miles south of Carthage is another very prominent dike over 150 feet wide. This dike, apparently in excellent condition, forms a ridge which stands about 30 feet above the surrounding country, and is thus very favorably located for quarrying. The rock is hard, tough and quite fresh and is an excellent road metal. Results of tests of this rock for road material are given on p. 266.

In the bed of a small branch of Killetts' Creek, three-quarters of a mile southwest of Carthage, a diabase dike about 100 feet wide is exposed.

A large and very favorably located dike 150 feet in width is crossed by Mill Swamp Creek about three-fourths of a mile north of Carthage. This dike extends across the country for more than a mile as a low ridge. The rock is apparently in excellent condition, hard and fresh, and so located that it could be readily quarried. Results of tests of this rock for road material are given on p. 266.

A large dike of good, fresh diabase is seen in the banks of Deep River near the mouth of McLendon's Creek, about 9 miles north of Carthage. This dike has a width of about 200 feet and occurs in such a manner as to be quarried with little difficulty.

The Deep River wagon road leading north from Carthage crosses three large diabase dikes. These are all in fair condition and will furnish vast quantities of rock. They are 200 feet, 150 feet and 100 feet respectively in width and are located 3, 4, and 6 miles from Carthage.

ORANGE COUNTY.

Only one dike of any importance was visited in this county. It is located near the old "University Quarry" (see p. 231), is about 150 feet wide, and is so located that it could be cheaply quarried. It occurs about $1\frac{1}{2}$ miles east of Chapel Hill. Results of tests of this rock for road material are given on p. 266.

In the following tables some data regarding the trend of the joint systems and the dikes have been tabulated to show the relation of the two.

Moore County.

Locality.	Trend of Joints.				Dikes.	
	Major set.	Second set.	Third set.	Fourth set.	Width.	Trend.
Donella's quarry, one and a half miles south of Sanford.....	N. 60° ± W.	N. 30° E.	E. & W.	.....	.....	.....
Donella's old quarry, one mile south of Sanford.....	N. 60° + W.	N. 30° E.	.....	.....	.....	.....
Donella's land, three-quarters mile south of Sanford.....	N. 60° ± W.	N. 30° E.	.....	.....	.....	.....
Stone Co.'s old quarry, half miles northwest of Sanford.....	N. 30-40° W.	N. 40-50° E.	E. & W.	.....	.....	.....
San Antonio Railway, three miles south of Cumstock.....	N. 30° W.	N. 40-50° E.	.....	.....	50 ±	N. 30° W.
Deep River, one and a half miles east of Gulf.....	N. 30° W.	N. 30-40° E.	.....	.....	.....	.....
Deep River, three-quarters mile west of Cumstock.....	N. 45° E.	E. & W.	N. & S.	.....	.....	.....
Donella's land, four miles northwest of Sanford.....	N. 30° W.	N. 30° E.	N. & S.	.....	.....	.....
Donella's land, one-half mile north of Sanford.....	N. 30° W.	N. 60° E.	.....	.....	.....	.....
Donella's land, three-quarters mile north of Sanford.....	N. 45° E.	N. 50° W.	.....	.....	.....	.....
Donella's land, one and a half miles north of Carthage.....	N. 15° E.	N. 60° W.	.....	.....	.....	.....
Donella's land, two miles northwest of Sanford.....	N. 15-45° E.	N. 65° E.	N. 50-60° W.	E. & W.	.....	.....
Donella's land, two and a quarter miles west of Carthage.....	N. 60° E.	N. 50° W.	E. & W.	.....	.....	.....
Donella's hill on McLendon's creek, half miles northwest of Sanford.....	N. 30° W.	N. 60° E.	.....	.....	125	N. 30° W.
Donella's land southeast of above.....	N. 30° W.	N. 60° E.	.....	.....	.....	.....
Donella's land on McLendon's creek, half miles southwest of Carthage.....	N. 45° E.	N. 45° W.	N. & S.	N. 80° E.	.....	.....
Donella's land, half mile south of above, along west side of creek.....	N. 45° E.	N. 45° W.	N. & S.	N. 80° E.	.....	.....
Donella's land on Suck Creek, nine miles southwest of Sanford.....	N. 30° E.	N. 45° W.	.....	.....	.....	.....
Donella's land, Crowley Creek, three miles south of Glendon.....	N. 30° W.	N. 60° E.	.....	.....	.....	.....
Donella's land, across Deep River, ten miles south of Carthage.....	N. 25° ± W.	N. 60° E.	.....	.....	75 +	N. 30° W.
Donella's land, southwest of the above.....	N. 30° W.	N. 60° E.	.....	.....	.....	.....
Donella's land, bridge across McLendon's creek, half mile south of above.....	N. 30° ± W.	N. 60° E.	.....	.....	75 ±	N. 30° W.
Donella's land, Stage road, three miles south of Carthage.....	Sandstone not exposed at dike.....	.....	.....	.....	75 ±	N. 25° ± W.
Donella's land, south of the dike near the Stage road.....	N. 30° W.	N. 60° E.	.....	.....	125	N. 30° W.
Donella's land, south of Stage road, half mile southwest of Carthage.....	Sandstone not exposed at dike.....	.....	.....	.....	200-300	N. 45° ± E.

Locality.	Trend of Joints.				Dikes.	
	Major set.	Second set.	Third set.	Fourth set.	Width.	Tr.
Black's old mill on Little River, seven miles south of Carthage.....	*Dike is in Coastal Plain.			.....	200	N.
Deep River wagon road, three-quarters of a mile northwest of Carthage.....	.....	.....	N. & S.	.....	150	N.
Deep River wagon road, three miles northwest of Carthage.....	N. 50° E.	N. 30° W.	.....	.....	200	N.
Deep River wagon road, four miles northwest of Carthage.....	N. 30° W.	N. 60° E. (?)	.....	.....	100	N.
Deep River wagon road, five and three-quarters miles northwest of Carthage.....	N. 30° W.	N. 60° E.	.....	.....	100	N.
Near mouth of McLendon's creek, nine miles northwest of Carthage.....	N. 30° W.	N. 60° E.	N. & S.	.....	200 (?)	N.
Branch of Killett's creek, three-quarters mile south of Carthage.....	N. 20° W.	N. 50° E. (?)	.....	.....	100	N.
Branch of Killett's creek, one and a quarter miles south of Carthage.....	N. 30° W.	N. 45° E.	.....	.....	.....	...
Carthage-Blacks' mill wagon road, one and a half miles south of Carthage.....	N. 20° W.	(?)	.....	.....	100	N.

* This dike is very near the contact between the Triassic and Coastal Plains formations. Joints in the sandstone this dike have the trend N. 30° ± W., N. 50° E.

Anson County.

Old Linehan quarry, one mile north of Wadesboro	N. 30° W.	N. 60° E.	.....	.....	100 +	N. 30° ±
800 yards northeast of Linehan quarry.....	N. 30° W.	N. 60° E.	.....	.....	100 +	N. 30° ±
W. A. Polk's quarry, one and a quarter miles northwest of Wadesboro.....	N. 30° W.	N. 60° E.	.....	.....	.....	.....
One-quarter mile southeast of Polk quarry	N. 30° W.	N. 60° E.	.....	.....	75 ±	N. 30° ±
Ansonville road, one mile northwest of Wadesboro	N. 30° W.	N. 60° E.	N. & S.	.....	3	N. & S.
Polkton road, one mile ± northwest of Wadesboro	N. 30° W.	N. 60° E.	N. & S.	.....	1	N. & S.
Polkton road, two miles west of Wadesboro	N. 30° W.	N. 60° E.	N. & S.	.....	Two small dikes.	N. & S.
Polkton road, two and a quarter miles west of Wadesboro	N. 30° ± W.	N. 60° ± E.	N. & S.	.....		N. 35°
Polkton road, three miles west of Wadesboro	N. 30° ± W.	N. 60° ± E.	.....	.....		N. 35°
Polkton road, three and a quarter miles west of Wadesboro.....	N. 30° ± W.	N. 60° ± E.	.....	.....		N. 35°
Polkton road, three and a half miles west of Wadesboro—Boggan's cut.....	N. 30° ± W.	N. 60° ± E.	.....	.....	Many small dikes.	N. 30-35
Brown's Creek, seven and a half miles northwest of Wadesboro.....	N. 40° ± W. (?)	N. 50° ± E. (?)	.....	.....		N. 30-35
Frank Hammond's quarry, two miles southwest of Wadesboro.....	N. 40° ± W.	N. 35° ± E.	.....	.....		N. 30-35
Gould's Fork, three miles northwest of Wadesboro	N. 55° ± W.	N. 30° E.	N. & S.	.....		N. 30-35
Wm. Parson's quarry, one-half mile west of Wadesboro	N. 55° ± W.	N. 30° E.	.....	.....		N. 30-35
I. Horton's quarry, three-quarters mile southwest of Wadesboro.....	N. 55° ± W.	N. 30° E.	.....	.....	600 ±	N. 45° ±
Near negro church in west limits of Wadesboro	Sandstone not exposed at dike.....			.....	100	N. 40° ±

Durham County.

Locality.	Trend of Joints.				Dikes.	
	Major set.	Second set.	Third set.	Fourth set.	Width.	Trend.
quarry, two miles east of	N. 15° E.	N. 60-70° W.	N. 55° E.	E. & W.	.....	.....
two and a half miles north-	N. 15° E.	N. 60° W.	N. 45° E.	.....	.....	.....
rd, one-quarter mile south-	N. 30° E.	N. 30° W.	.....	.....	.....	.....
field.....	N. 30° E.	N. 30° W.	.....	.....	.....	.....
le northwest of above.....	N. 30° E.	N. 30° W.	.....	.....	.....	.....
ree and a half miles south-	N. 30-40° E.	N. 30-40° W.	N. & S.	E. & W.	.....	.....
rd road, six miles south-	N. 35° E.	N. 30° W. (?)	.....	.....	100 +	N. 35° E.
rdham.....	N. 35° E.	N. 30° W. (?)	.....	.....	100 +	N. 35° E.
Southern Railway, three	Sandstone not exposed at dike.....	.....	.....	.....	600 ±	N. 15-30° E.
west of Durham.....	.....	.....	.....	.....	75	N. 45° E.
, three and a half miles	.....	.....	.....	.....	100 +	N. 25° ± E.
of Durham.....	.....	.....	.....	.....	150	N. 60° E.
ld road, two miles east of	.....	.....	.....	.....	.....	.....
.....
h road, two and a half	.....	.....	.....	.....	.....	.....
of Durham.....	.....	.....	.....	.....	.....	.....

Orange County.

rry, one and a half miles	N. & S.	E. & W.	N. 30° W.	N. 60° E.	150	N. & S.
apel Hill.....	N. & S.	E. & W.	N. 30° W.	N. 60° E.	150	N. & S.
three-quarters mile east of	.....	.....	.....	.....	20 ±	N. 15-20° W.
Il .....	.....	.....	.....	.....	50	N. 45° E.
thern Railway, three-quar-	.....	.....	.....	.....	.....	.....
orth of Chapel Hill.....	.....	.....	.....	.....	.....	.....

Wake County.

's farm, two and a half	N. 60° W.	N. 45° E.	N. & S.	.....	.....	.....
west of Morrisville.....	N. 60° W.	N. 45° E.	N. & S.	.....	.....	.....
lf miles west of the above	N. 30° W.	N. 60° E.	N. & S. (?)	.....	.....	.....
.....	N. 30° W.	N. 60° E.	N. & S. (?)	.....	.....	.....
land, three miles northwest	Sandstone not exposed at dike.	.....	.....	.....	50	N. 20° W.
ille	Sandstone not exposed at dike.	.....	.....	.....	50	N. 20° W.

Chatham County.

arry on Deep River, one	N. 30° W.	N. 30-40° E.	.....	.....	.....	.....
miles southeast of Gulf....	N. 30° W.	N. 30-40° E.	.....	.....	.....	.....
on Deep River, three-quar-	N. 45° E.	E. & W.	N. & S.	.....	.....	.....
west of Cumnock.....	N. 45° E.	E. & W.	N. & S.	.....	.....	.....
yards southeast of Gulf.....	Sandstone not exposed at dike.	.....	.....	.....	200 +	N. 45° W. (?)

Rockingham County.

sd, one mile northeast of	N. 20° E.†	.....	.....	.....	100	N. 20° E.
.....	N. 20° E.†	.....	.....	.....	100	N. 20° E.
d, eight miles northeast of	N. 20° E.†	.....	.....	.....	200	N. 20° E.
.....	N. 20° E.†	.....	.....	.....	200	N. 20° E.

ndstone was not exposed at either of these dikes, but observations made in other places show that a promi-
joints had a trend of N. 20° E.

in crystalline rocks, but having the same trend of the most prominent set of joints in the sandstone nearby.

CHAPTER VIII.

METHODS OF QUARRYING AND WORKING STONE.

The past twenty years have brought about a very marked change in the stone working industries; a change due mainly to the introduction of machinery. It is only in the smaller quarries and those catering to but a local market that recourse is still had to the old time hand drill. On a large scale, machinery does the work quicker, better and cheaper. Of the many machines now on the market, reference will here be made only to those in most general use.

In the quarrying of granite and other hard stone it is customary to drill a number of holes along the line it is desired that the stone shall break. These are then charged with a slow burning powder and fired simultaneously. By this means not merely is direction given but the force of the explosion is distributed over a considerable surface, thereby lessening the danger of shattering the stone. The drill holes in this work are commonly driven by a steam drill mounted on a tripod as shown in Figs. 5 and 6, and which is connected with the steam boiler by means of a flexible hose permitting the moving of the drill with comparative freedom. In a few cases, as at the Mt. Airy quarries, a different expedient is resorted to. This is explained on p. 157.

In quarrying soft stone, such as limestone, marble and sandstone, the use of powder is now almost wholly done away with, the stone being freed from the quarry bed by means of channelling and gadding machines. Several types of channelling machines are now in use. The oldest, and the one commonly used in the Vermont marble regions, is the Wardwell machine, shown in Fig. 7. This, as will be noted, is essentially a locomotive supplied on either side with gangs of cutting drills which are lifted and dropped as the machine travels backward and forward over the temporary tracks. Another type of machine for the same work, is the Ingersoll-Sargeant channeller shown in Fig. 8. This has the advantage that the drills can be inclined at any angle. The cut is made as a continuous slot some $1\frac{1}{2}$ to 2 inches in width, and of any desired depth up to 6 or 8 feet. After the channelling machines have done their work the blocks are freed from the bed by means of wedges introduced into a series of holes at right angles with the first cut. This underdrilling or under-



FIG. 5.—Eclipse rock drill.

cutting is called *gadding* and is also done by machinery. Two types of gadding machines are in common use, the one a diamond drill which bores a hole, and the other an impact drill which drives the hole in the ordinary manner. One of these, a special adaptation of the channelling machine, is used for the same purpose, shown in Fig. 9. It will be seen at once that the great advantage in the use of these machines lies in the fact that blocks of any desired size or shape can be taken out, and this too without the use of explosives. Where explosives, owing to local

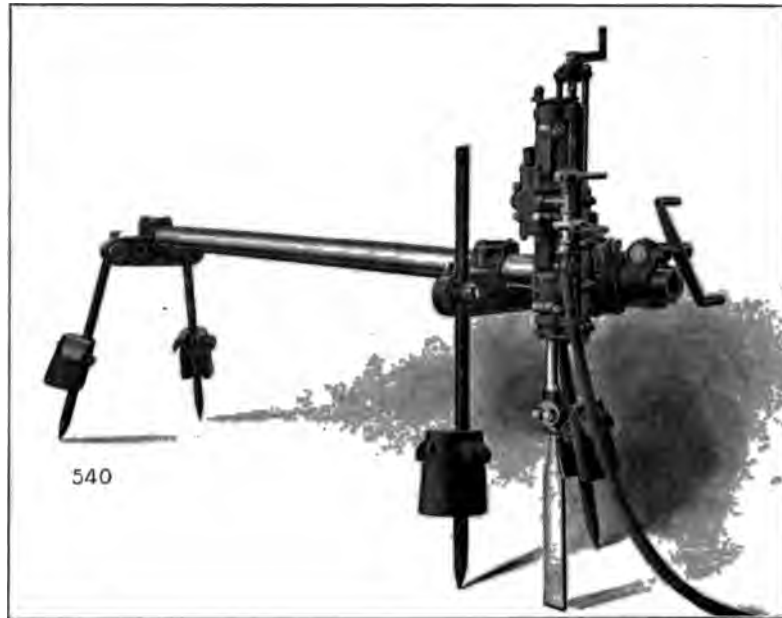


FIG. 8.—Ingersoll-Sergeant quarry bar drill.

conditions, must be used, recourse is had to the Knox or some similar method of blasting in which direction is given to the force of the explosion.

Freed from the quarry bed, the stone is reduced to the required size and shape by means of hand implements or by machinery, as the case may be. In squaring a stone or roughly reducing it to the required shape, the common means is by plug and feather. A series of small holes, some three-fourths of an inch in diameter, and from 3 to 6 inches deep, according to the character of the stone, is driven along the line it is desired the stone shall break. Into each of these is then fitted two

wedge-shaped half-round pieces of soft iron, called feathers, and a small steel plug or wedge placed between. The workman then moves along this line striking each wedge in turn until they all bind alike and a sufficient strain produced to cause the blocks to fall apart. Until very recently these holes have been driven altogether by small hand drills and hammers. A pneumatic drill is now coming into use which bids

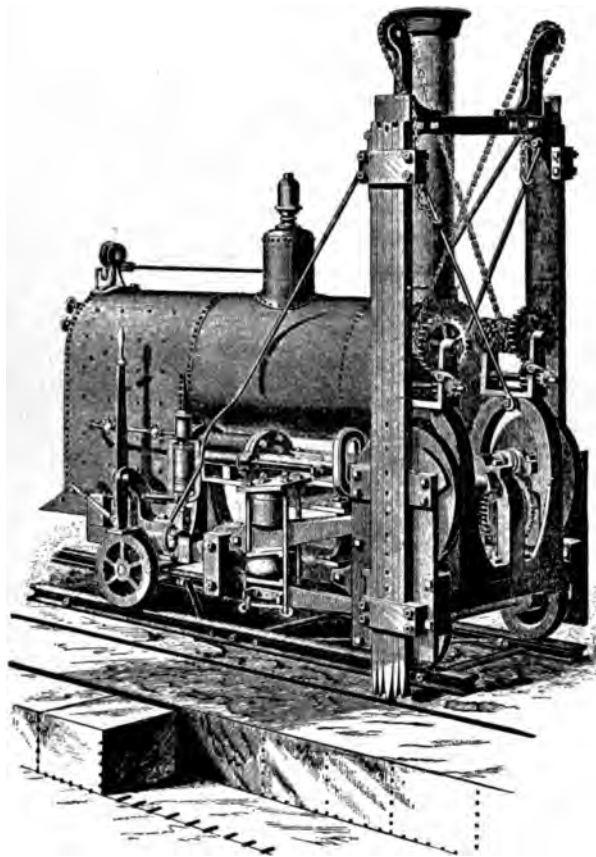


FIG. 7.—Wardwell double-gauge channelling machine.

fair to be very successful, Fig. 6 (see description of Mt. Airy quarries, p. 157).

The surface of the stone is worked down by hand implements, such as the point, chisel, tooth chisel, pitching chisel, drove, axe or pean hammer, and the patent or bush hammer. Here, too, machinery is coming into use as in the pneumatic stone-surfacing machine shown in Fig. 10.

Soft stone, like the limestones, marbles and sandstones, are sawed by means of thin blades of soft steel fed with sand and water. The saws are usually set in gangs, perhaps a dozen in a single frame. Sand



FIG. 8.—Ingersoll-Sergeant channelling machine.

composed of crushed steel or chilled iron is sometimes used as the cutting medium, but is liable to rust and stain the stone. Lathes are used by some of the larger firms for turning columns. A monster machine

of this nature in use at the Bodwell Granite Quarries, Vinalhaven, Maine, weighs 135 tons and will take a column nearly 60 feet in length. Planers are used for producing flat surfaces, and especial forms of the machine, for moldings.

REMARKS ON THE OPENING OF NEW QUARRIES.

In the work of opening a new quarry many matters, in part foreseen, or, again, unforeseen, come up for consideration, and it will be well to dwell upon some of these in detail, even though our remarks may be in the nature of platitudes to the experienced quarrier.



FIG. 9.—Ingersoll-Sergeant undercutting machine.

Throughout the entire region south of the glaciated areas, the quarrier is confronted with a condition of affairs quite unknown to his more northern collaborator. Everywhere but on the steepest hillsides, or where exposed to the sweeping action of running water, his outcrops are obscured by ferruginous sands and clays of varying depth which often prove a serious handicap to quarry operations, involving no small initial outlay in the work of clearing or *stripping*, as it is commonly called. This material is largely residual, that is to say, it has resulted from the decomposition of the rock and the gradual accumulation of the less

soluble portions on the surface. In the north the rocks likewise decomposed, but the debris was carried away by the ice sheet of the glacial epoch and the surface left hard and bare, ready for the quarrier. It is obvious that the southern quarrier is, at the outset, at a disadvantage; but that there are compensating conditions, will be noted later.

In opening a new quarry this residual mantle, or *regolith*,¹ as it has been called, must first be removed. Indeed, its partial removal is often rendered necessary before the extent and value of the quarry can be estimated, since it may so obscure all joints, flaws and natural defects of any kind as to make detailed observations impossible. The outcrops being visible, observations should be made as to the dip and strike of the beds, if the rock is sedimentary, their character, and the uniformity of the material. If the beds dip at a high angle, it follows that quarrying must be deep and expensive.

It having been decided to open a quarry, the matter of disposal of waste or quarry dump and drainage should receive early attention. Particular pains should be taken to remove the debris to such a distance that it cannot possibly interfere with future development. The first opening, while it may be small, should be so made as to allow indefinite expansion, without doing any of the work for a second time. Disregard of this rule through thoughtlessness or a desire to make the quarry pay from the start has brought grief to many a promising undertaking.

The drainage of a quarry is likewise an important matter. With quarries on a hillside, this is, as a rule, not difficult, but with those in a valley, as are the majority of the marble quarries of this State, pumping must often be resorted to, which, of course, adds to the cost of the output.

Blasting, if resorted to at all during the preliminary work of quarrying, should be conducted with care, and particularly so in the case of tender rocks like the marbles. Careless work will result in the fracturing of the beds and the ruin of material. And here it may be said that too much care cannot be exercised to prevent, during the early development of a quarry, at least, the shipment of poor material. A bad reputation once gained is hard to live down. An insufficient amount of capital has often seduced operators into the shipment of surface material, full of bad joints, shaky, and it may be, discolored. The writer saw blocks of this nature loaded on the cars during the progress of this investigation. To be sure, it was shipped as surface material, but, nevertheless, such is going to be seen and criticised by those who do not know all

¹ Rocks, Rockweathering, and Soils.



VIEW TO ILLUSTRATE EXCESSIVE JOINTING IN A QUARRY.



VIEW TO ILLUSTRATE EXCESSIVE JOINTING IN A QUARRY.

CHAPTER IX.

THE WEATHERING OF BUILDING STONES.

It long since became evident that not all stones were equally durable when removed from the quarry and placed in the walls of a building. This is naturally a more conspicuous feature in the old than the new world, but nevertheless many of our older cities contain only too many illustrations of this failing. Many an expensive piece of stone carving, monument or stone front is to-day in a sad state of disintegration and decay, even though it may have been exposed for no longer a period than that covered by the life of its builder. The city of New York affords hundreds of illustrations of decayed house fronts, some of which are in so advanced a stage of disintegration as to make them actually unsightly.

The causes of this disintegration are manifold, and have been elaborated elsewhere by Dr. Merrill.¹ The chief causes are the physical agencies of heat and cold, and the chemical agencies of solution in the water of rainfalls. These may be touched upon briefly here.

It is a well known fact that under the influence of heat, stone like most other substances will expand, and contract under that of cold. A stone in the walls of a building, or lying upon the surface of the ground, will therefore be subject to the expansive action of the sun's heat during the day, and contraction by cold at night. The greater extremes of heat and cold the greater the expansion and contraction. At the extreme, the amount of change is slight for a single day, and not appreciable perhaps for a year, except to a trained observer. Nevertheless the daily repetition of the process in the extremes of night and day, of summer and winter, gradually weathers a stone on its immediate surface so that disintegration may result and the surface of a finely tool-dressed stone may become decidedly roughened within a comparatively few years. The freezing of water absorbed into the pores of a stone is a still more energetic source of disintegration; hence, stones capable of absorbing a considerable amount of water, more than 3 or 4 per cent by weight, are to be regarded as of doubtful durability in a climate where there is an abundant rainfall and where the temperature sinks frequently below the freezing point.

¹ See *Rocks, Rockweathering, and Soils*, Macmillan Co., N. Y., and *Stones for Building and Decoration*, Wiley & Sons, N. Y.

Another cause of decay in a building stone is the solubility of certain of its constituents in the water of rainfalls. That any stone is really appreciably soluble in water may strike one as at first remarkable. Nevertheless it is true that many stones, and particularly limestones, are soluble in the water brought down by rainfalls, and sometimes so to a marked degree. The natural outcrops of beds of marble and limestone are often fluted and corroded in a marked degree by this means. Indeed the phenomena of a limestone cave is but an illustration of the solvent power of water on a larger scale. Stones which are of a uniform texture, as when composed of pure carbonate of lime, will often dissolve away so smoothly that the results are quite inconspicuous even after years of exposure. When, however, a stone is of uneven texture, as in the case of a sandstone with a calcareous cement, the result may be more serious, particularly where the removal of this cement renders the stone more absorptive and hence more liable to the unfavorable influence of frost.

A slight change in color is a by no means uncommon accompaniment of weathering. The more common change is one that takes place in rocks carried from below the water level and in which a small amount of iron, presumably in solution, is in the form of a carbonate, sometimes as a sulphide in the form of finely disseminated iron pyrites. When the iron is evenly disseminated in small quantity, there may result a slight yellowing of the stone, i. e., the color changes from a dull gray or white to a slight buff tint. Where the iron is present as pyrite (or marcasite) in quantity, the weathering results in dull, dark and ferruginous blotches, which are quite unsightly.

THE TESTING OF BUILDING STONE.

In consideration of the facts above mentioned many tests have been devised, having in view the determination, in the laboratory, and within comparatively brief period, the effect of prolonged exposure upon any one it might be proposed to use. The tests most commonly resorted to are made with a view of ascertaining (1) the crushing strength, (2) the resistance to shearing forces, (3) the elasticity, (4) the ratio of expansion and contraction, (5) the absorptive power and resistance to freezing, (6) the fireproof properties, (7) corrodability, and (8) color changes.

Crushing Tests.—The first comprehensive and systematic series of tests of this nature in the United States were those made by General Q. A. Gilmore² of the U. S. Army engineers, the results of which were pub-

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² Ann. Rep. Chief of Engineers, U. S. A., 1875.

lished in 1875. The methods employed have naturally been somewhat improved upon since Gilmore's time, but the changes are by no means radical. These and other tests are only touched upon somewhat briefly here, as the main purpose of this report is to describe in detail the building and ornamental stones of the State.

The common method employed in this test, then, consists in subjecting a carefully prepared cube of the stone to actual crushing, by means of specially designed machines.³ Pressure is applied to the two opposite faces of the cube, the size of which, as experimented on by different individuals, is somewhat variable; commonly either two or four inches on a side. The crushing strength as shown by the machine is usually given as a certain amount per square inch of crushing surface. Thus, if a cube whose crushing faces were exactly two inches on a side (comprising four square inches) is crushed under a weight of 60,000 pounds, its crushing weight would be given as 15,000 pounds per square inch.

Many hundreds and even thousands of tests of this nature have from time to time been made. Indeed, it is the test which has received attention above all others. The present writer has often stated his views⁴ to the effect that the value of such tests is greatly overrated. To be sure, great strength is, to some extent, indicative of density, but it cannot always be accepted as indicating durability. It is not too much to say that a large portion of the tests made to-day are not worth their cost. This for the reason that any stone not so inherently weak as to be rejected on mere inspection will be found sufficiently strong for all practical purposes. The number of instances in which a stone in the walls of a building, arches and abutments of bridges, has crushed through actual weakness are so few as to be ignored. Stones break through the presence of flaws, or scale at the joints, from a lack of cement, but do not crush. Sufficient tests have already been made along the established lines to give us general principles, and for that reason few have been attempted in the present investigation. These few are described on page 236, and, as will be seen, were made to ascertain the strength of porous materials when dry, saturated with moisture, and after freezing.

Architects and engineers still occasionally demand pressure tests, however, and for the benefit of those who wish such made, it may be well to state that in the preparation of the cube to be tested care should be taken to select blocks free from defects and to have them reduced to the proper

³ One of the best-known machines for this work is made by the Rhie Bros., of Philadelphia.

⁴ See *Stones for Building and Decoration*, Wiley & Sons, N. Y.

TABLE SHOWING STRENGTH PER SQUARE INCH, SPECIFIC GRAVITY,
WEIGHT PER CUBIC FOOT, AND RATIO OF ABSORPTION
OF STONE OF VARIOUS KINDS.

Kind of stone.	Locality.	Size of cube.	Position.	Strength per square inch.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.
Granodiorite.	Rocklin, Cal.	2.96x3.96x3.96.		21,817	2.68	167.25	.054
Granite.	Lawson, Colo.	2.0x2.07.	Bed	17,512	2.62	163.99	.006
Granite.	Millford, Mass.	4.06x4x4.06.		30,888			
Granite.	Hurricane Is., Maine.	2.017x2.018x2.022.		19,583			
Granite.	Cape Ann, Mass.	6x4x11.93.		20,296			
Granite.	East St. Cloud, Minn.	2x2x2.	Bed	23,000			
Granite.	Barr, Vt.	2x2.06x2.04.		19,957	2.67	166.87	trace
Granite.	Richmond, Va.			25,520			.008
Granite.	Athelstane, Wis.	2x2x2.		20,145	2.70	167.95	
Militic limestone.	Bedford, Indiana.		Bed	10,125		152.39	.031
Compact dolomite.	Lemont, Indiana.	2x2x2.	Bed	12,000	2.64	165.3	.011
Crystalline dolomite.	Lee, Mass.	11.99x5.88x3.98.		18,047			
Crystalline limestone.	Pickens Co., Ga.	1x1x1.	Bed	13,400	2.76	172.6	
Crystalline limestone.	Carara, Italy.	2x2x2.	Bed	12,156	2.69	163.2	.025
Sandstone.	Portland, Conn.		Bed	13,310	2.36	148.5	
Sandstone.	Berea, Ohio.	2x2x2.	Bed	10,250	2.11	131.9	.000

size and shape through sawing and grinding rather than by chisel and hammer—a method liable to develop flaws.

In order to illustrate the relative strength of stones of the different classes, the table on page 257 has been compiled from various sources.

Shearing Tests.—The term shearing, as here used, includes strains due not only to pressure in one direction, but others due to pulling or thrusting in all directions up to those perpendicular to the first. It is a form of strain likely to be brought to bear on stone in many parts of a building and in bridges. The test, as performed by the army engineers, consists in subjecting prepared blocks or prisms supported at either end by blocks six inches apart, to a downward thrust applied by means of a plunger having a face five inches wide, there being a clearance space of half an inch between the sides of the plunger and the supporting blocks. The details of this and the other physical tests are given in the reports on the testing of metals, etc., by army engineers at the Watertown (Mass.) Arsenal, and need not be repeated here.

Elasticity Tests.—These are of two kinds, (1) those made to ascertain the elasticity under compressive, and (2) those under transverse strains. The compressive elasticity test is made on prisms some 4 inches by 6 inches by 24 inches, the loads being applied from the ends, i. e., in the direction of the longer axes, the problem being to ascertain not merely the amount of compression the stone will undergo, but also its power of regaining its first position and size when the pressure is removed. Obviously the amount of such compression is small, and can be measured only with very delicate instruments. It has been found in tests of this kind that the stones when thus treated shortly develop a permanent set; that is, would not quite recover from the compression during the period covered by the observations.

The transverse elasticity test consists in bringing pressure to bear upon bars of stone supported at the ends (as in the shearing tests), except that the supports are farther apart and the pressure is applied at the middle. The amount of deflection or bending of the bar, without rupture, is of course dependent largely upon its elasticity, the term modulus of rupture signifying the weight in pounds under which a bar one inch in diameter resting upon supports one inch apart will break, as calculated from the tests.

Ratio of Expansion and Contraction.—Tests of this nature are of great interest and are extremely suggestive, as giving a clew to the weathering

qualities. Unfortunately, they are very delicate, requiring special apparatus, and are expensive. But few such have been made. The method of testing consists in placing a carefully prepared and measured bar of stone in a vessel of water, of known temperature, and gradually raising the temperature to a point 100° C. above that at the beginning of the experiment. The gradual lengthening of the bar during the increase in temperature is noted, as is its gradual shortening on cooling. Though but few tests have been made, it has been shown that few if any rocks will, on cooling, quite regain their former dimensions. The difference, though measured it may be by but the ten-thousandths of an inch, is important since it means that cleavage planes in the individual minerals, and minute spaces between the minerals themselves have been developed, and that as a consequence the rock is not only weaker, but will prove more absorptive and more liable to injury from frost.

Absorptive Power and Resistance to Freezing.—The amount of moisture any stone will absorb is dependent very largely upon the amount of space between the granules composing it. As a rule, crystalline rocks are not strongly absorptive, the individual granules being very closely compacted. But among the so-called fragmental rocks, such as the sandstones, the granules are not in all cases closely compacted, and there may be thousands of minute interstitial cavities which will permit the absorption of a very considerable amount of water. Such stones not merely give rise to damp walls, but are liable to disintegration through the freezing of this absorbed water. Figures showing the *ratio of absorption*, that is the relative proportion of weight which various stones will absorb, are given in the tables showing resistance to crushing, on page 257. Others, as made of North Carolina materials, are given on page 236. Tests to ascertain the ratio of absorption are made by simply immersing a prepared and weighed cube of stone in water and then boiling the water, or placing the vessel containing it under a bell jar and removing the air by an air-pump. This permits the water to enter all the pores. The cube is then removed and weighed after removing the excess of water on the outside by means of blotting paper. The increase in weight of the cube is of course the weight of the absorbed water and from it the percentages are calculated. The resistance of the stone to the action of frost is ascertained by subjecting the cubes to repeated freezing and thawing while in a saturated condition. At the conclusion of each period of thawing the loosened granules, if such there be, are brushed from the surface, and the cube weighed at the conclusion of the tests. The loss in weight shows then the resisting power. Enough tests of this nature have

size and shape through sawing and grinding rather than by chisel and hammer—a method liable to develop flaws.

In order to illustrate the relative strength of stones of the different classes, the table on page 257 has been compiled from various sources.

Shearing Tests.—The term shearing, as here used, includes strains due not only to pressure in one direction, but others due to pulling or thrusting in all directions up to those perpendicular to the first. It is a form of strain likely to be brought to bear on stone in many parts of a building and in bridges. The test, as performed by the army engineers, consists in subjecting prepared blocks or prisms supported at either end by blocks six inches apart, to a downward thrust applied by means of a plunger having a face five inches wide, there being a clearance space of half an inch between the sides of the plunger and the supporting blocks. The details of this and the other physical tests are given in the reports on the testing of metals, etc., by army engineers at the Watertown (Mass.) Arsenal, and need not be repeated here.

Elasticity Tests.—These are of two kinds, (1) those made to ascertain the elasticity under compressive, and (2) those under transverse strains. The compressive elasticity test is made on prisms some 4 inches by 6 inches by 24 inches, the loads being applied from the ends, i. e., in the direction of the longer axes, the problem being to ascertain not merely the amount of compression the stone will undergo, but also its power of regaining its first position and size when the pressure is removed. Obviously the amount of such compression is small, and can be measured only with very delicate instruments. It has been found in tests of this kind that the stones when thus treated shortly develop a permanent set; that is, would not quite recover from the compression during the period covered by the observations.

The transverse elasticity test consists in bringing pressure to bear upon bars of stone supported at the ends (as in the shearing tests), except that the supports are farther apart and the pressure is applied at the middle. The amount of deflection or bending of the bar, without rupture, is of course dependent largely upon its elasticity, the term modulus of rupture signifying the weight in pounds under which a bar one inch in diameter resting upon supports one inch apart will break, as calculated from the tests.

Ratio of Expansion and Contraction.—Tests of this nature are of great interest and are extremely suggestive, as giving a clew to the weathering

qualities. Unfortunately, they are very delicate, requiring special apparatus, and are expensive. But few such have been made. The method of testing consists in placing a carefully prepared and measured bar of stone in a vessel of water, of known temperature, and gradually raising the temperature to a point 100° C. above that at the beginning of the experiment. The gradual lengthening of the bar during the increase in temperature is noted, as is its gradual shortening on cooling. Though but few tests have been made, it has been shown that few if any rocks will, on cooling, quite regain their former dimensions. The difference, though measured it may be by but the ten-thousandths of an inch, is important since it means that cleavage planes in the individual minerals, and minute spaces between the minerals themselves have been developed, and that as a consequence the rock is not only weaker, but will prove more absorptive and more liable to injury from frost.

Absorptive Power and Resistance to Freezing.—The amount of moisture any stone will absorb is dependent very largely upon the amount of space between the granules composing it. As a rule, crystalline rocks are not strongly absorptive, the individual granules being very closely compacted. But among the so-called fragmental rocks, such as the sandstones, the granules are not in all cases closely compacted, and there may be thousands of minute interstitial cavities which will permit the absorption of a very considerable amount of water. Such stones not merely give rise to damp walls, but are liable to disintegration through the freezing of this absorbed water. Figures showing the *ratio of absorption*, that is the relative proportion of weight which various stones will absorb, are given in the tables showing resistance to crushing, on page 257. Others, as made of North Carolina materials, are given on page 236. Tests to ascertain the ratio of absorption are made by simply immersing a prepared and weighed cube of stone in water and then boiling the water, or placing the vessel containing it under a bell jar and removing the air by an air-pump. This permits the water to enter all the pores. The cube is then removed and weighed after removing the excess of water on the outside by means of blotting paper. The increase in weight of the cube is of course the weight of the absorbed water and from it the percentages are calculated. The resistance of the stone to the action of frost is ascertained by subjecting the cubes to repeated freezing and thawing while in a saturated condition. At the conclusion of each period of thawing the loosened granules, if such there be, are brushed from the surface, and the cube weighed at the conclusion of the tests. The loss in weight shows then the resisting power. Enough tests of this nature have

been made to show as a whole the sandstones are the most absorptive, and also that any stone that will absorb more than five per cent by weight of water needs to be regarded with suspicion until it shall have actually proven its value. It may be remarked, further, that pressure tests applied to stones of the same kind in a dry and saturated condition, show a marked falling off in strength in the saturated cubes. This is shown in the table on page 236, in which cubes essentially two inches in diameter were experimented upon.

Fire Tests.—It becomes occasionally desirable to learn the power of a stone to resist heat, or the rapid alterations of heat and cold. With the steady improvement in the methods of fireproof construction, such tests will become from year to year of less consequence and indeed are even now rarely resorted to. Tests that have thus far been made show that of all stone, certain of the siliceous sandstones and trappean rocks are most nearly fireproof, the coarse granites being the least so. The tests as performed are very simple and consist in merely heating a weighed block in a muffled furnace to a bright red heat, and then, while still hot, plunging it into a vessel of cold water.

Corrodibility and Color Tests.—The test of corrodibility, or resistance to corrosion, is an important one where stone is to be subjected to the slightly acidulated water of rainfalls, as in manufacturing towns and cities. It is especially applicable to calcareous rocks, that is, to limestones and marbles, or sandstones containing a calcareous cement. Tests of this nature have, in years past, been made by Profs. A. W. Jackson, of Berkeley, California, and J. A. Dodge, of the University of Minnesota.* For corrodibility, specimens of essentially the same size and weight are selected, dried and weighed. They are then suspended by strings in a vessel of water through which a stream of carbonic acid gas is kept constantly bubbling. This action is kept up for several weeks, when the specimens are removed, dried and weighed, the loss in weight indicating the corrodibility, i. e., the amount of material removed in solution by the carbonic acid water. As a rule in such tests the amount lost is very small; in the case of siliceous rocks scarcely appreciable, but in calcareous rocks sometimes as much as one per cent. Tests for permanence of color, as performed by these same authorities, were as follows: Dried and weighed samples of the stone were placed on glass shelves in a porcelain dish containing strong hydrochloric (muriatic) acid. Close by were then

* See Final Rep. Geol. & Nat. Hist. Survey of Minnesota, Vol. I, and Ann. Rep. State Mineralogist of California for 1888.

placed open bottles one of which contained strong nitric acid and the other hydrochloric acid and a little manganese oxide, the whole being then covered by a bell glass. The chlorine and acid fumes rising and filling the chamber form an extremely corrosive and oxidizing mixture, and quickly attack any oxidizable compounds where such exist. The tests in cases of this kind should extend over a period of several weeks.

Abrasive Tests.—Occasionally, when stone is to be used as in flooring, tiles, or street pavements, tests for determining the relative wearing qualities are desired. This is usually done by noting the rapidity of wearing down on a grinding bed. Such tests are of little value, however, except in the case of very homogeneous material.

By far the most satisfactory way for ascertaining the power of any stone to withstand the weather is to study it in its natural outcrops, old quarry exposures, and in old buildings. This method has been pursued in the present investigation to the almost entire exclusion of all others. The climate of the State of North Carolina is sufficiently variable, so far as heat and cold are concerned, and there is a sufficiently heavy precipitation to try the stone severely. That they are affected by these influences is shown by the layers of soil, and rock residues that everywhere cover the rocks, except where removed by erosion. But the havoc as seen here is that of ages untold in years; we must accept the results guardedly, therefore, and not too hastily condemn a rock because its outcrops are buried in its own debris. We want the comparative rate of decomposition rather than actual, knowing that the best is surely good enough, and that the worst may be safely rejected.

APPENDIX.

STONE FOR ROAD BUILDING.

The demand for good roads, within recent years so enhanced through the introduction of the bicycle and automobile, has stimulated activity, not merely in road-building but in the study of road materials as well.

The forms of pavement most used in this country, where traffic is too heavy for dirt roads, are those known as the Belgian block pavement and macadam. The first consists of roughly broken, but approximately rectangular blocks of stone, some 4 inches by 6 inches by 10 inches in size, which are set in the roadbed in parallel rows, about an inch apart, the interstices being filled with sand and tar or asphalt. Such a road, while well suited for heavy traffic, has proven altogether too rough and noisy for residence streets and is too expensive for suburban and country roads.

For these last situations, the form of pavement now most in favor is that known as macadam, named for its inventor, an English road engineer who brought the method of construction into prominence as long ago as 1820. The utility of the invention, if such it can be called, is based upon the well-known property of stone, whereby broken particles will, when subjected to the friction of wheels and the pounding hoofs of animals, undergo a process of recementation which is due in part to the breaking away from the larger masses of fine angular particles, which gradually become compacted in their interstices, until the whole is converted into a moderately firm rock-mass again. Macadam is laid by different builders either with or without a layer or foundation of larger stones. Such a foundation, where used, is from 6 to 12 inches in thickness. Over this is laid from four to six inches of broken stone or *road metal*, as it is sometimes called. The size of this broken stone is dependent upon the amount of traffic and the quality of the material. The best size for hard stones, like the trap rock and close-grained granite, is given as from $\frac{1}{2}$ to $1\frac{1}{2}$ inch cubes, while, in the softer stones, pieces from $\frac{1}{2}$ to $2\frac{1}{4}$ inches are used. On roads for light driving it is customary to place a fine surfacing of small stone, such as will pass through an inch mesh. Upon the character of this final surfacing is dependent, to a considerable extent, the quality of the road.

The chief essentials of stone to be used for macadam are hardness, toughness and cementing power. Concerning these qualities, the following is quoted:

"By hardness is meant the power possessed by a rock to resist the wearing action caused by the abrasion of wheels and horses' feet. Toughness, as understood by road builders, is the adhesion between the crystal and fine particles of a rock, which gives it power to resist fracture when subjected to the blows of traffic. This important property, while distinct from hardness, is yet intimately associated with it, and can in a measure make up for a deficiency in hardness. Hardness, for instance, would be the resistance offered by a rock to the grinding of an emery wheel; toughness, the resistance to fracture when struck with a hammer. Cementing or binding power is the property possessed by the dust of a rock to act after wetting as a cement to the coarser fragments composing the road, binding them together and forming a smooth, impervious shell over the surface. Such a shell, formed by a rock of high cementing value, protects the underlying material from wear and acts as a cushion to the blows from horses' feet, and at the same time resists the waste of material caused by wind and rain, and preserves the foundation by shedding the surface water. Binding power is thus, probably, the most important property to be sought for in a road-building rock, as its presence is always necessary for the best results. The hardness and toughness of the binder surface more than of the rock itself represents the hardness and toughness of the road, for if the weight of traffic is sufficient to destroy the bond of cementation of the surface, the stones below are soon loosened and forced out of place. When there is an absence of binding material, which often occurs when the rock is too hard for the traffic to which it is subjected, the road soon loosens or ravel.

"Experience shows that a rock possessing all three of the properties mentioned in a high degree does not under all conditions make a good road material; on the contrary, under certain conditions it may be altogether unsuitable. As an illustration of this, if a country road or city park way, where only a light traffic prevails, were built of a very hard and tough rock with a high cementing value, neither the best, nor (if a softer rock were available) would the cheapest results be obtained. Such a rock would so effectively resist the wear of a light traffic that the amount of fine dust worn off would be carried away by wind and rain faster than it would be supplied by wear. Consequently, the binder supplied by wear would be insufficient, and if not supplied from some other source, the road would soon go to pieces. The first cost of such a rock would in most instances be greater than that of a softer one, and the necessary repairs resulting from its use would also be very expensive."¹

Naturally, with material so weighty as stone, the cost of transportation is great. Hence, a large portion of the mass of any road must be of materials from nearby sources. It is with this fact in mind that the ob-

¹ See also, The Testing of Road Materials by Logan Waller Page, Bull. No. 79, Bureau of Chemistry, U. S. Dept. of Agriculture.

servations here detailed have been made. Samples of material from quarries in operation as well as from outcrops which, from their locality seem promising, have been collected and submitted to tests at the Road Material Laboratory of the Department of Agriculture. The results are given in the accompanying table.

In explanation of these results, it may be stated that, as a rule, a stone having a high or medium *co-efficient* of wear, a low *percentage* of wear, a high cementing value, and a low ratio of absorption will give the best results on the average road.

It will be noticed that all the rocks listed are low in cementing value. Fortunately, this is a defect which can usually be easily remedied by adding a thin top dressing of some material having a high cementing value, such as clay, gravel, or some other rock high in this property. If clay is used, care must be taken not to add too much. In no case should a layer more than one-fourth of an inch thick be used.

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RESULTS OF TESTS MADE ON NORTH CAROLINA STONE SUITABLE FOR ROAD METAL.—Continued.

No.	Serial No. Road Material Laboratory.	Locality.	Kind of Material.	Coefficient of wear.	Per cent of wear.	Wt. in lbs. per cu. ft.	Lbs. of water absorbed per cu. ft.	Comment- ing value.	Sp. gr.	Page on which the stone is described
30.	810	<i>Henderson County.</i> Ballfour.	Granite gneiss.	12.4	3.2	162.5	.1	1	2.6	169
31.		<i>McDowell County.</i> Marion— $\frac{3}{4}$ mile SE.	Biotite gneiss.	17.8	2.3	163.8	.2	1	2.7	168
32.		Woodlawn.	Dolomite (limestone).	8.6	4.7	181.3	.3	4	2.9	202
33.	772	<i>Madison County.</i> Hot Springs—1 mile W.	Dolomite (limestone).	7.2	5.5	181.3	.2	20	2.9	209
34.	771	Hot Springs	Quartzite.	12.3	3.3	162.5	.2	8	2.6	—
35.	504	Hot Springs—1 mile W.	Dolomite (limestone).	9.5	4.2	181.3	.1	2	2.9	209
36.	811	<i>Mecklenburg County.</i> Charlotte—City quarry.	Granite.	17.5	2.3	168.8	.2	5	2.7	67
37.	384	<i>Moore County.</i> Pinehurst.	Gravel.	...	...	....	..	24	..	—
38.	840	Carthage—Black's mill.	Olivine diabase (trap).	14.5	2.8	181.3	.3	4	2.9	230
39.	841	Carthage—Swamp Creek.	Diabase (trap).	15.1	2.7	181.3	.6	15	2.9	240
40.	401	<i>New Hanover County.</i> Wilmington.	Phosphate conglomerate.	3.2	18.7	156.3	2.5	124	2.5	203
41.	402	Wilmington.	Fossiliferous limestone.	4.	9.9	147.4	2.7	127	2.4	205
42.	403	Wilmington.	Limestone (decomposed).	...	...	....	..	110	..	205
43.	884	<i>Orange County.</i> Chapel Hill.	Olivine basalt (trap).	14.6	2.7	187.5	.1	3	3.0	240
44.	885	Hillaboro—1 mile SW.	Altered diabase (trap).	29.6	1.4	187.5	.1	6	3.0	54
45.	514	<i>Randolph County.</i> Aahboro.	Felsite (apophyllite).	21.3	1.9	168.8	.02	2	2.7	—
46.	826	<i>Richmond County.</i> Rockingham—Steel's Mill.	Hypersthene gabbro (trap).	12.3	3.2	187.5	1.04	3	3.0	—
47.	808	<i>Rowan County.</i> Granite Quarry Station.	Granite.	20.8	1.9	162.5	.13	3	2.6	106
48.	764	<i>Surry County.</i> Elkin.	Hornblende-schist.	9.1	4.4	187.5	.2	8	3.0	—
49.	814	Mt. Airy.	Granite.	9.3	4.3	168.6	.2	1	2.7	153
50.	431	<i>Wilson County.</i> Elm City.	Granite.	14.2	2.8	163.8	.4	3	2.7	23
51.	432	Wilson—Contentnea Creek.	Granite.	6.2	6.4	162.5	.4	9	2.6	21
52.	433	Wilson—Contentnea Creek.	Granite.	7.2	5.6	162.5	.2	20	2.6	21

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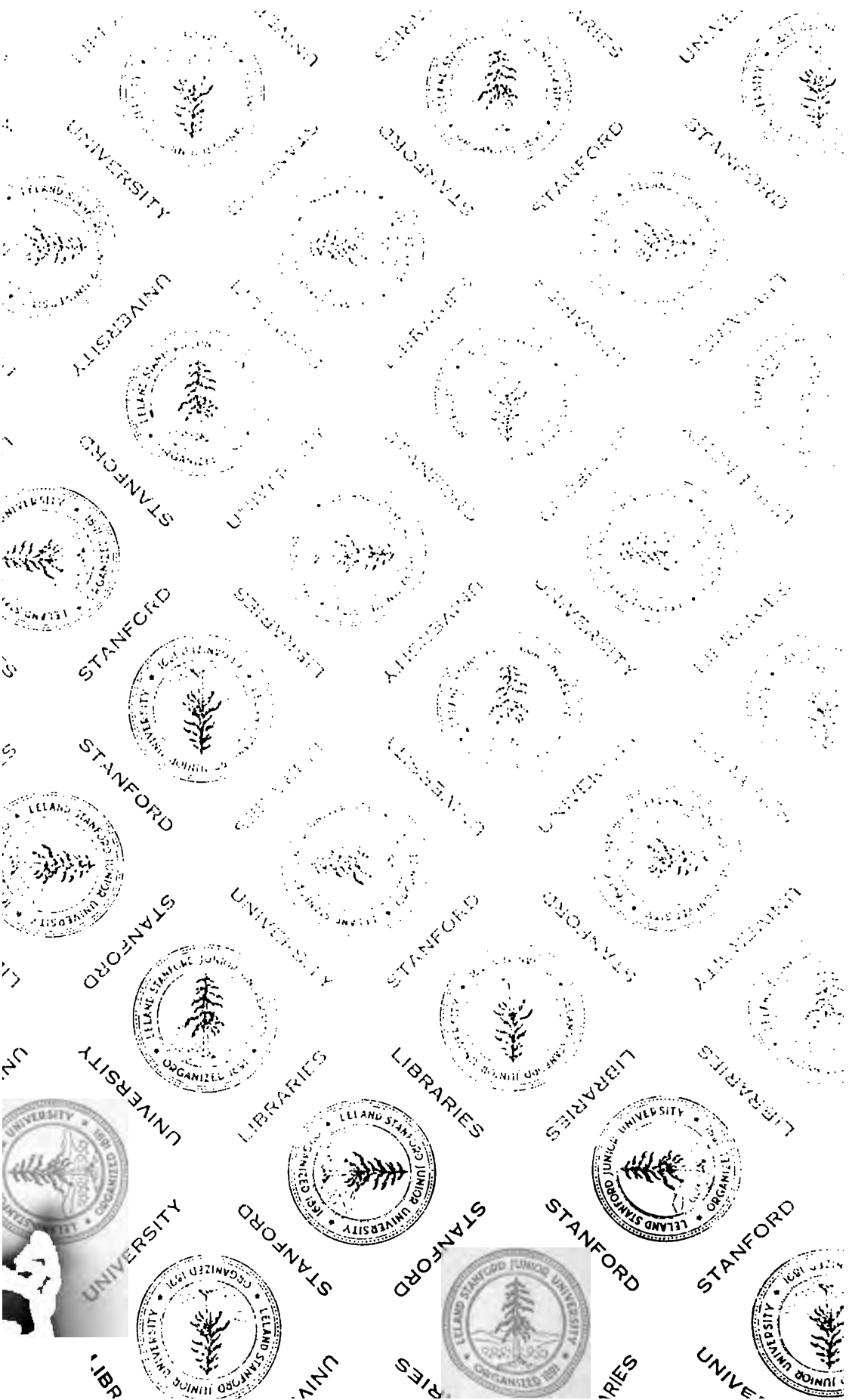
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